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GeoScience Abstracts

Vol. 1, No. 4 April 1959

published monthly by the
AMERICAN GEOLOGICAL INSTITUTE

GEOSCIENCE ABSTRACTS

published by the
American Geological Institute

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GeoScience Abstracts is published monthly, beginning with Volume 1, Number 1, January 1959, and replaces Geological Abstracts which was discontinued by the Geological Society of America at the end of 1958. The journal has received a grant in aid from the National Science Foundation to provide initial working funds.

GeoScience Abstracts will work toward complete coverage of all significant North American literature in geology, solid earth geophysics and related areas of science. It will also include abstracts in English of Soviet literature, particularly from the Referativnyi Zhurnal, as the translations are processed by the AGI Translation Center. The journal will have a monthly author index and an annual subject index.

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2101 Constitution Avenue, N.W., Washington 25, D. C.

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CONTENTS

		Page
1.	Geologic Maps, Areal and Regional Geology (including Guidebooks)	1
2.	Geomorphology	5
3.	Structural Geology	7
4.	Stratigraphy and Historical Geology	8
5.	Paleontology	11
6.	Geophysics	14
7.	Geochemistry	20
8.	Mineralogy and Crystallography	27
9.	Igneous and Metamorphic Petrology	31
10.	Sedimentary Petrology	31
11.	Geohydrology	32
12.	Mineral Deposits (including Geochemical Prospecting)	33
13.	Fuels	67
14.	Engineering Geology	No entries this month
15.	Miscellaneous	68

SERIALS

The following list gives in full the abbreviated citations used after the titles of papers in this issue of GeoScience Abstracts.

American Association of Petroleum Geologists, Bulletin. Tulsa, Oklahoma.
American Ceramic Society, Journal. Easton, Pennsylvania.
American Geophysical Union, Transactions. Washington, D. C.
American Mineralogist (Mineralogical Society of America). Ann Arbor, Michigan.
Arizona Bureau of Mines, [Maps]. Tucson, Arizona.
Bulletins of American Paleontology (Paleontological Research Institution). Ithaca, New York.
California Institute of Technology, Division of Geological Sciences, Contribution. Pasadena, California.
Canada, Geological Survey, Map; Paper. Ottawa.
Ciencia. Mexico, D. F.
Columbia University, Lamont Geological Observatory, Contribution. Palisades, New York.
Deutsche Geologische Gesellschaft, Zeitschrift. Hannover, Germany.
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Franklin Institute, Journal. Philadelphia.
Geochemistry [Geokhimiya]; a translation of the journal of the Academy of Sciences, U. S. S. R., devoted to geochemistry (Geochemical Society). Ann Arbor, Michigan.
Geological Society of America, Bulletin. New York.
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Illinois, State Geological Survey, Circular. Urbana, Illinois.
International Geology Review (American Geological Institute). Washington, D. C.
Journal of Geophysical Research. Washington, D. C.
Journal of Paleontology. Tulsa, Oklahoma.
Kansas, State Geological Survey, Miscellaneous Report. Lawrence, Kansas.
Los Angeles, University of Southern California, Allan Hancock Foundation for Scientific Research, Contribution.
Manitoba, Dept. of Mines and Natural Resources, Mines Branch, Publication. Winnipeg, Manitoba.
Maryland, Dept. of Geology, Mines and Water Resources, Bulletin. Baltimore, Maryland.
Michigan, University, Dept. of Mineralogy, Contribution. Ann Arbor, Michigan.
Micropaleontology (American Museum of Natural History). New York.
Mineral Industries (Pennsylvania State University, College of Mineral Industries). University Park, Pennsylvania.
Mining Engineering (American Institute of Mining, Metallurgical and Petroleum Engineers). New York.
Montana Bureau of Mines and Geology, Bulletin; Geological Investigations Map. Butte, Montana.
National Speleological Society, Bulletin. Alexandria, Virginia.
New Mexico, Bureau of Mines and Mineral Resources, Bulletin; Geologic Map; Memoir; Scenic Trips to the Geologic Past. Socorro, New Mexico.
New York State Museum and Science Service, Geological Survey, Newsletter. Albany, New York.
Palaeontology (Palaeontological Association). London.
Pennsylvania State University, College of Mineral Industries, Contribution. University Park, Pennsylvania.
Professional Geographer (Association of American Geographers). Washington, D. C.
Quebec (Province), Dept. of Mines, Preliminary Report. Quebec.
Research Council of Alberta, Geological Division, Bulletin. Edmonton, Alberta.
Science. Washington, D. C.
Shell Development Company, Exploration and Production Research Division, Publication. Houston, Texas.
United Nations, Economic Commission for Asia and the Far East, [Mineral Resources Development Series].
U. S. Geological Survey, Bulletin; Oil and Gas Investigations Map. Washington, D. C.
Washington, University, Dept. of Meteorology and Climatology, Contribution. Seattle, Washington.

GeoScience Abstracts

1. GEOLOGIC MAPS, AREAL AND REGIONAL GEOLOGY

PART 1. GEOLOGIC MAPS

See also: Miscellaneous 1-1060

1-800. Heywood, W. W. LEDGE LAKE AREA, MANITOBA AND SASKATCHEWAN: Canada, Geol. Survey, Map 24-1957, scale 1 in. to 1,000 ft., marginal notes, 1958.

Preliminary-series geological map of a small area S. of Flin Flon, Manitoba. Most of the area is underlain by variously metamorphosed volcanic rocks of Precambrian age ascribed to the Amisk group. These have a general northwesterly trend, and the various types are interlayered and interfingered in complex repetitions. In part crossing these layers and in part following their general trend are several large and small bodies of rocks varying from granite to quartz diorite. A few isolated patches of greywacke and conglomerate are correlated with the Missi series. A small patch of Ordovician dolomite crossing the southern border is either a tongue from, or an outlier of, the large area of Paleozoic rocks that lie to the S. --H. M. A. Rice.

1-801. Podolsky, T. CRANBERRY PORTAGE (WEST HALF), MANITOBA: Canada, Geol. Survey, Map 26-1957, scale 1 in. to 1 mi., marginal notes, 1958.

Preliminary-series map of about 170 sq. mi. SE. of Flin Flon. The area is underlain by a very irregular, discontinuous, tightly folded belt of altered volcanic rocks (Amisk group) of Archean age roughly trending NE. These rocks are surrounded by, and in part intercalated with, younger granitic rocks of Archean or Proterozoic age... Quartz veins are common in the area, and some are known to carry Au and others sulfides. Some sulfide replacement bodies, mainly pyrrhotite, are known. --H. M. A. Rice.

1-802. Fraser, J. A. HARDISTY LAKE (WEST HALF), DISTRICT OF MACKENZIE, NORTHWEST TERRITORIES: Canada, Geol. Survey, Map 2-1958, scale 1:253,440, marginal notes, 1958, 2 refs.

Preliminary-series geological map of some 2,100 sq. mi. lying between Great Slave and Great Bear lakes. Most of the area is underlain by small areas of metamorphosed Precambrian sedimentary and igneous rocks and much larger bodies of granite and allied rocks. In the SW. corner, the Precambrian rocks are covered by flat-lying Paleozoic sediments that extend far to the S. and W. beyond this map-area. Pitchblende occurs in some quartz veins and stockworks. --H. M. A. Rice.

1-803. Eade, K. E., W. W. Heywood, and H. A. Lee. SAKAMI LAKE AREA, NEW QUEBEC: Canada, Geol. Survey, Map 23-1957, scale 1 in. to 8 mi., marginal notes, 1958, 5 refs.

Preliminary-series geological map of an area 5° by 3° on the eastern side of James Bay and southeastern Hudson Bay. This was a helicopter-supported operation covering a large area in one season, and detailed geological mapping was not attempted. By far the greater part of the area is underlain by Archean granitic rocks, gneisses and schists derived from sediments and volcanic rocks. Proterozoic sediments form a fringe along the shore of Hudson Bay and occur in a few small fault blocks in the interior. --H. M. A. Rice.

1-804. Heywood, W. W., S. E. Brett, K. L. Currie, and K. E. Eade. LA GRANDE - LAC BEINVILLE, NEW QUEBEC: Canada, Geol. Survey, Map 23-1958, scale 1 in. to 8 mi., marginal notes, 1959.

Preliminary series geological map of an area 4° by 4° in extent on the western side of the Labrador peninsula. This was a helicopter-supported operation, and detailed geological mapping was not attempted. Most of the area is underlain by granitic rocks, granite gneisses, and gneisses and schists clearly derived from sedimentary and volcanic rocks. In the southern part of the area are some small areas of greenstone and recognizable lavas with intercalated pyroclastic rocks and sediments. There is one small pluton of pyroxenite. All these are of Archean age, but in the northern part of the area are a few small areas of Proterozoic sediments, possibly remnants of once much more extensive beds. --H. M. A. Rice.

1-805. Fahrig, W. F. WOLLASTON LAKE, SASKATCHEWAN: Canada, Geol. Survey, Map 27-1957, scale 1 in. to 4 mi., marginal notes, 1958.

Preliminary-series map of some 2,500 sq. mi. in northern Saskatchewan along the Manitoba border. Nearly all the area is underlain by metamorphosed Archean sediments, largely altered to gneiss, and foliated granite. All are tightly folded in a northeasterly direction. The W. side of the area laps onto the edge of the large area of flat-lying Proterozoic rocks lying S. of Lake Athabasca. --H. M. A. Rice.

1-806. Taylor, F. C. PELICAN NARROWS, SASKATCHEWAN: Canada, Geol. Survey, Map 1-1958, scale 1 in. to 4 mi., marginal notes, 1958, 5 refs.

Preliminary-series geological map of some 5,400 sq. mi. of Precambrian rocks NW. of Flin Flon, Manitoba. Most of the area is underlain by schists and gneisses, those in the E. half of the area predominantly of sedimentary origin and those in the W. half of volcanic origin, although intercalated sedimentary gneisses are also common in the latter part and narrow bands of hornblende-rich gneiss are common in the former. Most of the rocks are more or less granitized, and irregular bodies of granite, granodiorite, quartz diorite, and pegmatite occur all over the area. All rocks have been complexly folded, and near the center area is a persistent northerly-trending fault. Rocks E. of this fault, most of which are included with the Kisseynew gneisses, are more highly metamorphosed than those to the W. of it. --H. M. A. Rice.

1-807. Tremblay, L. P. URANIUM CITY, SASKATCHEWAN, SHEET 6: Canada, Geol. Survey, Map 25-1957, scale 1 in. to 800 ft., marginal notes, 1958.

Preliminary-series map of a small area a short distance N. of Uranium City. The area is underlain by both Archean and Proterozoic rocks, the former tightly folded in a northwesterly direction but much

contorted and dislocated by cross faults. The Proterozoic sediments belong to the Athabasca group and have a similar trend but are in much more open folds.

Pitchblende occurs as small lenses in some of the fissures, and one property has reached small-scale production. --H. M. A. Rice.

1-808. Poole, W. H. WOLF LAKE, YUKON TERRITORY: Canada, Geol. Survey, Map 22-1957, scale 1 in. to 4 mi., marginal notes, 1958.

Preliminary-series map of some 1,500 sq. mi. immediately N. of the British Columbia border, along the Alaska Highway. The oldest dated rocks are fossiliferous Lower Cambrian limestone apparently underlain by quartzite and more limestone. The structure is somewhat obscure, but it seems probable that some at least of these rocks are Precambrian. Overlying these is a succession of Silurian, Devonian, and Carboniferous sediments more or less metamorphosed. These are intruded by late Mesozoic granite. The youngest consolidated rocks are flat-lying basalts of late Tertiary or early Pleistocene age.

The sediments lie in 2 northwesterly-trending synclines separated by an anticlinal area largely occupied by granitic rocks. Several faults with much the same trend were recognized.

Although ore minerals, including cassiterite and wolframite, are widely distributed, only placer gold has as yet been produced, and that principally in the last century. --H. M. A. Rice.

1-809. U. S. Geological Survey. STATUS OF TOPOGRAPHIC MAPPING IN THE UNITED STATES: scale 1:5,000,000, Jan. 1959.

This status map shows topographic and planimetric quadrangle maps produced by the U. S. Geological Survey and other Federal agencies and published at various scales ranging from 1:24,000 to 1:250,000. Mapped areas are designated in colored patterns. Areas covered by maps published at scales less than 1 in. to 1 mi. are marked in green; maps with scales 1 in. to 1 mi. or greater, in red or blue. Patterns are used to differentiate modern maps, maps in need of revision, maps of limited usefulness, maps in need of resurvey, planimetric maps, maps in progress (new mapping, remapping, and revision), and the U. S. topographic series published at 1:250,000 scale. --G. E. Denegar.

1-810. Geological Society of America. GLACIAL MAP OF THE UNITED STATES EAST OF THE ROCKY MOUNTAINS: 2 sheets, scale 1:1,750,000, 1959, refs.

This map was compiled and edited by a committee of the Division of Earth Sciences, National Research Council, Washington, D. C., consisting of Richard Foster Flint (Chairman), Yale University; Roger B. Colton, U. S. Geological Survey; Richard P. Goldthwait, The Ohio State University; and H. B. Willman, Illinois State Geological Survey.

Colored map units indicate marine sediments; lacustrine sediments; outwash sediments; ice-contact stratified drift; end moraines of Wisconsin age; drift, other than end moraines and outwash, of Wisconsin age; end moraines of Illinoian age; other Illinoian drift; Kansan and Nebraskan drift; and non-glaciated areas. The implied limits of glaciation shown are based on the occurrence of continuous and discontinuous till. Isolated erratics, many of which have been ice rafted, are not shown. Much of the drift is covered with loess and eolian sand, which is not mapped.

Indicated by symbols are end-moraine crests, washboard moraines, outer limits of significant glacial advance, inferred outer limit of major drift sheet beneath younger drift, strandlines, spillways, striation direction, streamline features, boulder trains, and outer limit of glaciation by Rocky Mountain glaciers.

Footnotes supplement the map. Both published and unpublished sources of data are listed. --G. E. Denegar.

1-811. Wilson, Eldred D., and Richard T. Moore. GEOLOGIC MAP OF MOHAVE COUNTY, ARIZONA: Arizona Bur. Mines, Univ. Arizona, scale 1:375,000, 1959.

Compared with the 1924 Geologic Map of Arizona, the County Geologic Maps contain much additional detail and more accurately delineate the geology because of a more accurate base map. A more comprehensive separation of rock units has been made, especially of the volcanic rocks and of the Precambrian crystalline rocks. --R. T. Moore.

1-812. Waagé, K. M. STRATIGRAPHY OF THE DAKOTA GROUP ALONG THE NORTHERN FRONT RANGE FOOTHILLS, COLORADO: U. S. Geol. Survey, Oil & Gas Inv. Map OC-60, 1959.

The Dakota group in this area has been revised to include the Lytle formation and the overlying South Platte formation. The probable correlation of these formations with their lithic equivalents in adjacent areas of Wyoming and Colorado is shown. Also shown are detailed columnar sections of possible oil- and gas-bearing rocks of Cretaceous age. The stratigraphy of the Dakota group is summarized in a short text. --U. S. Geol. Survey.

1-813. Poulter, Glenn J. GEOLOGY OF THE GEORGETOWN THRUST AREA SOUTHWEST OF PHILIPSBURG, MONTANA: Montana Bur. Mines & Geology, Geol. Inv. Map no. 1, scale 1:40,000, 1958.

The area studied in detail comprises about 200 sq. mi. in Granite and Deer Lodge counties. Sedimentary rocks include 20,000 ft. of Precambrian Belt rocks, 5,500 ft. of Cambrian, Devonian, Mississippian, and Pennsylvanian rocks, and a few hundred feet of Cenozoic rocks. Granules composed of minnesotaite, siderite, and silica are described from a thin zone within the Precambrian Missoula group. Morainal deposits are tentatively correlated with the "Bull Lake"(?), "Pinedale"(?), "Temple Lake"(?), and "Little Ice Age"(?) glacial advances of Wisconsin age.

There is evidence for an early, probably Paleocene, phase of Laramide compression which initiated movement on the Georgetown thrust and produced N.-trending structures. During a late Laramide phase of compression (early? Eocene), NE.-trending structures developed, and the main displacement occurred on the Georgetown thrust.

Remnants of erosion surfaces are preserved at various levels in this area. The "old surface," preserved at elevations of from 9,000 to 9,500 ft., reflects a cycle of peneplanation lasting until late

Miocene time which was interrupted at late maturity. The "intermediate surface," at elevations which range from 6,200 to 5,500 ft., is made up of pediments which formed under semiarid climatic conditions in late Tertiary to Quaternary time. Pediments have not previously been reported for the Northern Rocky Mountain Province. The "young surface" is marked by the flood plains of the present streams. --Auth.

1-814. Smith, Clay T., and others. GEOLOGIC MAP OF FOSTER CANYON QUADRANGLE, VALENCIA AND McKINLEY COUNTIES, NEW MEXICO: New Mexico, Bur. Mines & Mineral Resources, Geol. Map 9, scale 1:48,000, 1958.

1-815. Zeller, Robert A., Jr. RECONNAISSANCE GEOLOGIC MAP OF DOG MOUNTAINS QUADRANGLE: New Mexico, Bur. Mines & Mineral Resources, Geol. Map 8, scale 1:62,500, 1958.

1-816. Zeller, Robert A., Jr. RECONNAISSANCE GEOLOGIC MAP OF PLAYAS FIFTEEN-MINUTE QUADRANGLE: New Mexico, Bur. Mines & Mineral Resources, Geol. Map 7, scale 1:62,500, 1958.

1-817. Panhandle Oil Explorer. TEXAS PANHANDLE - ANADARKO BASIN DEVELOPMENT MAP: scale 1 in. to 8000 ft., Amarillo, Texas, Jan. 1959.

This 40 x 60 in. blue line geological map shows all oil and gas wells and fields in Hansford, Hutchinson, Ochiltree, Roberts, Lipscomb, and Hemphill counties in the NE. Texas Panhandle. Field names are shown and producing horizons in each well are indicated by symbolic coding. Subdivisions of the following major geologic horizons (Mississippian-Permian) are used to indicate producing pay in each well: Wolfcamp, Virgil, Missouri, Des Moines, Atoka, Morrow, Chester. Map also shows acreage division into section, block and survey; cities and towns. --G. E. Denegar.

1-818. U. S. Geological Survey. STATUS OF TOPOGRAPHIC MAPPING IN AREAS OUTSIDE OF CONTINENTAL UNITED STATES: 9 maps on 1 sheet, scales 1:4,000,000, 1:2,000,000, 1:1,000,000, 1:500,000, 1:250,000, Jan. 1959.

This status map shows topographic quadrangle maps produced by the U. S. Geological Survey and other Federal agencies and published at various scales ranging from 1:20,000 to 1:250,000. Maps cover areas in Alaska, American Samoa, Guam, Hawaii, Midway, Panama Canal Zone, Puerto Rico, Virgin Islands, and Wake. Mapped areas are designated in colored patterns. Areas covered by maps published at scales less than 1 in. to 1 mi. are marked in green; maps with scale 1 in. to 1 mi. or greater, in red or blue. Patterns are used to differentiate modern maps, maps in need of revision, maps of limited usefulness, maps in need of resurvey, work in progress (new mapping, remapping, and revision), and U. S. and Alaska topographic series published at 1:250,000 scale. --G. E. Denegar.

PART 2. AREAL AND REGIONAL GEOLOGY

See also: Structural Geology 1-843, 1-846; Stratigraphy 1-853; Geohydrology 1-955; Mineral Deposits 1-990, 1-992, 1-997, 1-1000.

1-819. Armstrong, J. E. SURFICIAL GEOLOGY OF NEW-WESTMINISTER MAP-AREA, BRITISH COLUMBIA: Canada, Geol. Survey, Paper 57-5, 25 p., illus., fig. (in pocket), Map 16-1957 (in pocket), scale 1 in. to 1 mi., 1958, 7 refs.

Preliminary report on 390 sq. mi. along the International Boundary SE. of Vancouver. The earliest dated deposits are of the Quadra non-glacial interval which, from a C^{14} analysis of contained wood, was found to be over 30,000 years old. Older than these are tills and related deposits of the Seymour interval. Above the Quadra sediments are more tills and related glacial deposits of the Vashon interval which are in turn overlain after a marked interval of erosion by deposits related to the last (Vashon) glaciation. Since then sedimentation has been continuous at one part or another of the area, those deposits no longer being formed being referred to the Capilano, and those still being deposited to the Salish. A slight complexity is introduced by the presence among the Capilano sediments of tills (Sumas) formed by valley glaciers. C^{14} analyses suggest that the Capilano was being deposited around 11,250 to 11,350 years ago and the Vashon 11,800 years ago.

The presence of extremely thick (in places over 2,100 ft.) unconsolidated deposits poses many problems of engineering geology, such as flood control, sewage disposal, and heavy construction. --H. M. A. Rice.

1-820. Tedlie, W. D. GEOLOGY OF THE BARLOW LAKE AREA: Manitoba, Dept. Mines & Nat. Resources, Mines Branch, Pub. 57-2, 23 p., 2 geol. maps (1 in pocket, scale 1:31,680), table, 1958, 4 refs.

A brief treatment of lithology, structure, and metamorphism of Wasekwan series (Precambrian) of an area E. of Lynn Lake, Manitoba, the type area for the Wasekwan. Most of the Barlow Lake area is underlain by granitic intrusives and granite gneiss surrounding remnants of metamorphosed Wasekwan volcanic and sedimentary rocks. Fold structures are uncertain; numerous topographic lineaments [exist], at least some of which are faults. Few indications of economic mineral deposits [occur] in the area. --J. F. Davies.

1-821. Baragar, W. R. A. AHR LAKE MAP-AREA, NEW QUEBEC: Canada, Geol. Survey, Paper 57-7, 6 p., illus., Map 21-1957 (in pocket), scale 1 in. to 1 mi., 1958, ref.

Preliminary report on some 340 sq. mi. of the Canadian shield in the "Labrador Trough." Rocks of the map-area may conveniently be grouped into 3 northwesterly-trending belts: sedimentary schists in the NE., predominantly volcanic rocks in the center, and predominantly sedimentary rocks in the SW. All are believed to be of Proterozoic age. Basic and ultrabasic sills intrude the rocks of the 2 last-named belts in great profusion.

Occurrences of sulfide minerals are numerous and widespread, but concentrations of economic interest are few. Some iron-formation is present

in the belt of sedimentary rocks. --H. M. A. Rice.

1-822. Murphy, Daniel L. PRELIMINARY REPORT ON MOUNT WRIGHT AREA, SAGUENAY ELECTORAL DISTRICT: Quebec, Dept. Mines, Prelim. Rept. no. 380, 7 p., fold. geol. map (Prelim. Map no. 1260), scale 1:63,360, 1959, ref.

The Mount Wright area (52°30'-52°45'N. 67°15'-67°30'W.), investigated in summer 1958, covers approx. 180 sq. mi. about 180 mi. NNW. of Sept-Iles. All consolidated rocks are Precambrian and consist, in order of abundance, of paragneiss, paraschist and granulite(?); metasedimentary iron formation, marble and quartzite; basic metaigneous rocks; and granite pegmatite. Relatively thin Pleistocene and Recent deposits of sand, clay, gravel and erratic boulders cover the bedrock in over 60% of the map-area. Eskers, kame terraces and other glacial features are common.

Structure is complex. One of the largest and best-exposed structures is the NE.-plunging Mount Wright syncline. In the southern part of the area where bedrock is fairly well exposed, folding is much more complex. Structures have a dominant NW. trend. Evidence of faulting and shearing is sparse. Joints are common throughout.

The iron formation offers the greatest economic possibilities. The most important unit, the specularite-oxide facies, contains 35% Fe. The magnetite-oxide facies may contain as much as 25-30% Fe, but deposits are small and of doubtful economic value. Several companies hold claims in the area. N. of Mount Wright, near Mogridge Lake, some gabbroic intrusions contain cobalt. The western part of the area warrants further study. --A. C. Sangree.

1-823. Roscoe, S. M. CAMBRIAN LAKE (EAST HALF), NEW QUEBEC: Canada, Geol. Survey, Paper 57-6, 13 p., illus., Map 18-1957 (in pocket), scale 1 in. to 4 mi., 1958, 5 refs.

Preliminary report on 2,650 sq. mi. of the Canadian shield, in the northern part of the New Quebec-Labrador Fe belt. In the SW. part of the area, sedimentary rocks unconformably overlie granite. These sedimentary rocks are subdivided into 5 major map-units. Red beds and slate, dolomite, grey slate, iron-formation, and argillite and quartzite. They underlie most of the SW. half of the map-area. A broad belt of basic igneous rocks comprising metabasalt, metagabbro, and pyroclastic rocks with some intercalated sedimentary rocks crosses the northeastern part of the map-area. NE. of this belt are garnetiferous biotite gneisses and schists. Intensity of metamorphism increases from low chlorite facies to amphibolite facies from W. to E.

No major unconformities or large-scale faults are known to separate the 3 main work types, and they are collectively known as the Kaniaspiskau group. They are probably of Proterozoic age.

Some Fe ore deposits in the area have been explored but are not at present of economic importance. Bornite and chalcopyrite are present at several places, and at least one occurrence has been explored. --H. M. A. Rice.

1-824. Stearn, C. W. PRELIMINARY REPORT ON CAUSAPSCAL AREA (EAST HALF), MATAPÉDIA ELECTORAL DISTRICT: Quebec, Dept. Mines, Prelim. Rept. no. 382, 10 p., fold. geol. map (Prelim. Map no. 1262), scale 1:63,360, 1959, 5 refs.

The E. half of the Causapscal area (48°15'-48°30'N. 67°-67°15'W.) mapped in summer 1958, covers about 200 sq. mi. on the E. side of the Matapédia river near the base of the Gaspé Peninsula. The land surface is a dissected upland. The map-area is underlain by Silurian and Devonian sandstones, siltstones, slates and limestones constituting a section over 20,000 ft. thick. In the southern part of the area a lens of intermediate volcanic rocks about 700 ft. thick is intercalated in the slates.

The formations were deformed during the Devonian into broad folds and high angle faults. A small dike was intruded into the Devonian sediments after folding. The Laurentide ice sheet covered the area, as indicated by scattered erratic boulders, but Pleistocene deposits are rare except in the Matapédia valley.

Associated Developments Causapscal No. 1 well was abandoned at 4,696 ft. before reaching reefal limestones of the Sayabec formation (Silurian), but considerable interest has continued in oil and gas possibilities of western Gaspé. No mineral occurrences of economic importance have been found. --A. C. Sangree.

1-825. Foster, Roy W. SOUTHERN ZUNI MOUNTAINS: New Mexico, Bur. Mines & Mineral Resources, Scenic Trips to the Geologic Past, no. 4, 55 p., illus., 1958.

The "Scenic Trips to the Geologic Past" booklets are published by the New Mexico Bureau of Mines and Mineral Resources to acquaint the visitor, as well as the New Mexico resident, with the many scenic and geological attrations which are found in the State.

In addition to a road log, a summary of the geologic, archeologic, and more recent history of the southern Zuni Mountains area is given.

The Zuni Mountains are a broad elongate dome almost completely ringed by high inward-facing cliffs. The cliffs consist of a series of sedimentary rocks that once formed a continuous blanket over the area now occupied by the mountains. During the uplift of the range, which began somewhere around 70 million years ago, the sedimentary rocks were tilted and eroded back from the core of the dome. The more resistant layers, such as sandstone, now appear as cliffs, whereas the softer beds, such as shale, now form slopes and valleys. Since the uplift of the mountains began, there has been considerable volcanic activity in the area, activity that ended as recently as 1,000 years ago. --New Mexico, Bur. Mines & Mineral Resources.

1-826. Morgan, James P., and William G. McIntire. QUATERNARY GEOLOGY OF THE BENGAL BASIN, EAST PAKISTAN AND INDIA: Geol. Soc. America, Bull., v. 70, no. 3, p. 319-41, 6 illus. on 2 pls., 9 figs. incl. 7 maps, graphs, secs., March 1959, 37 refs.

Reconnaissance of the Bengal provinces of East Pakistan and India indicates that structural activity, primarily faulting, has significantly influenced Quaternary geology. Two areas of Pleistocene terrace border the Bengal basin on the E. and W. and flank Tertiary and older hills of India. Two large inliers of Pleistocene sediments within the basin are surrounded by Recent flood-plain deposits of the Ganges and Brahmaputra rivers and their combined deltaic plain.

Block faulting and echelon faulting have so disturbed the topography of the Pleistocene terrace that the reconnaissance was insufficient to permit determination of whether multiple terraces are present within the basin. Faulting and structural uplift have continued into the Recent epoch, necessitating a physiographic subdivision into an early and a late phase.

Changes in the courses of the Ganges and Brahmaputra rivers through Bengal during the last few hundred years can be attributed to faulting and resultant tilting of fault blocks. These changes have caused the Ganges to abandon numerous western distributaries in favor of joining the Brahmaputra-Meghna system to the SE. At present about 12,000 sq. mi. of former Ganges deltaic plain in SW. Bengal has been abandoned.

A series of surface echelon faults plus evidence of structural control of stream courses suggest the presence of a subsiding structural trough or major fault at depth. This active structural zone apparently has controlled both the Brahmaputra and Ganges rivers in their lower reaches. Subsurface information is lacking, but this subsiding trough may possibly be related to the arcuate chain of mountains in adjacent Burma. --Auth.

2. GEOMORPHOLOGY

See also: Geologic Maps 1-810; Areal and Regional Geology 1-819; Geohydrology 1-953; Fuels 1-1051.

1-827. Flint, Richard Foster. PLEISTOCENE CLIMATES IN EASTERN AND SOUTHERN AFRICA: Geol. Soc. America, Bull., v. 70, no. 3, p. 343-73, 8 figs. incl. maps, profiles, sec., March 1959, 71 refs.

Pleistocene climates in the southern half of Africa are indicated by evidence of lakes in regions now dry, ancient soils for whose development the climate is now too dry or too wet, inactive wind-blown sand now covered by vegetation, and signs of former glaciation. Such features indicate climates different from those now prevailing. In addition, anomalies in the distribution of living organisms seem to support the assumption of climatic change.

Most of the evidence indicates change in annual amount or seasonal distribution of rainfall, but some suggests former temperatures lower, possibly by as much as 5°C., than those of today. Few of the features discussed are well fixed stratigraphically, but most of them are probably late Pleistocene.

The atmospheric-circulation pattern shows that annual amount and seasonal distribution of rainfall differ markedly in various regions in the subcontinent. The current literature contains a start toward a reconstruction of former patterns which are compatible with the geologic and biogeographic evidence, based on analogies with modern anomalies.

Although probable, the theory that pluvial climates in Africa were contemporaneous with glacial climates in Europe remains unsupported by geologic evidence, mainly because data are very few. --Auth.

1-828. LaChapelle, E. R. ANNUAL MASS AND ENERGY EXCHANGE ON THE BLUE GLACIER: Jour. Geophys. Research, v. 64, no. 4, p. 443-49, map, cross-sec., 4 graphs, Apr. 1959, 4 refs.; also pub. as: Washington, Univ., Dept. Meteorology & Climatology, Contr. no. 42.

Field work and techniques of observation at the IGY station at 2010 m. elevation on the Blue Glacier, Mount Olympus, western Washington State, are briefly described. The annual mass exchange on this glacier is large. Only very shallow penetration of subfreezing temperatures occurs, and the winter energy deficit is due almost entirely to increased ice mass. The 1958 ablation season, being long and hot, resulted in a specific mass deficit of 1.7 m. water and a corresponding specific energy gain of 1.36×10^4 cal./cm^2 During the 1958 melt season the principal sources of heat to the melting snow surface were, in order of importance, solar radiation, eddy conduction, and water vapor condensation. Of this heat, 64.4% was used for ice melt, and the remainder was lost to long-wave radiation cooling and heat of vaporization. Net water vapor transfer at the snow surface was small, but it played a measurable role in the over-all heat balance. --Auth.

1-829. Martinelli, M., Jr. SOME HYDROLOGIC ASPECTS OF ALPINE SNOWFIELDS UNDER SUMMER CONDITIONS: Jour. Geophys. Research, v. 64, no. 4, p. 451-55, graph, 4 tables, Apr. 1959, 9 refs.

Ablation, density, and weather factors were measured at selected snowfields in the Front Range of Colorado during the summers of 1955 and 1956. Water equivalent of ablation and moisture exchange between the atmosphere and the snow surface were computed.

Ablation varied from 1.1 to 2.8 ft. per week. It averaged 1.9 ft. per week for July, Aug., and the first half of Sept. Density of the snow increased during the summers, reached a maximum during Aug., and then decreased slowly. For each acre of snow existing on Aug. 1, about 11 1/2 acre-ft. of water were released by ablation during July and Aug. This amounted to 0.19 acre-ft. of water per day per acre of snow. Sverdrup's equation indicated that net moisture exchange between the atmosphere and the snow averaged less than 2% ablation. Proposals are made to sustain stream flow into the summer by constructing barriers to drift additional snow into natural accumulation areas. --Auth.

1-830. Curl, Rane L. A STATISTICAL THEORY OF CAVE ENTRANCE EVOLUTION: Natl. Speleol. Soc., Bull. no. 20, p. 9-22, diag., 2 graphs, 3 tables, Nov. 1958, 4 refs.

As there are caves with one or more entrances there should logically be caves with no entrances. Using data on the number of caves with one or more entrances the expected frequency of caves with no entrances was worked out. A simple mechanism of entrance evolution was assumed. The following hypotheses have been designed to express the evolution of cave entrances:

1) the probability (or fraction) of caves with n entrances losing one entrance in a time interval Δt is equal to $sn\Delta t$, where the proportionality constant s is a function of the influences of the environment;

2) the probability of caves of length l gaining an entrance in a time interval Δt is equal to $rl\Delta t$, where the proportionality constant r again depends on the environment;

3) the probability of caves of length l and with n entrances neither gaining or losing an entrance in a time interval Δt is equal to $1-ns\Delta t-rl\Delta t$.

Studies were made on caves in West Virginia and Pennsylvania. --G. E. Denegar.

1-831. Halliday, William R. AN INITIAL SURVEY OF CAVES OF THE HAWAIIAN ISLANDS: Natl. Speleol. Soc., Bull. no. 20, p. 58-60, Nov. 1958, 3 refs.

The Hawaiian Islands are almost entirely composed of volcanic rocks, which amounts for the fact that lava tubes and sea caves are the predominant types of caverns. The island of Oahu has few caves if sea caves and blow holes are excepted. Sea caves of moderate size are developed in the Honolulu volcanics near Koko Head and elsewhere. The most important cave on the island appears to be Makua Cave, formed by wave action along "a fault crack" and the margins of 2 parallel, cross-jointed, resistant dikes.

Two important sea caves are to be found on the N. shore of Kauai near Haena. Many major lava tubes occur on the island of Hawaii, and sea caves are well developed on the islets of Kaula and Lehua. --G. E. Denegar.

1-832. Link, Cord H., Jr. BIG ROOM CAVE OF PAYNE COVE: Natl. Speleol. Soc., Bull. no. 20, p. 1-8, 9 figs. incl. illus., maps, Nov. 1958, ref.

The relation of caverns to surface features has often been a matter for speculation. Detailed topographic maps and accurate mapping of caverns in the Payne Cove area, Tennessee, demonstrates the close relation of cavern and surface features. A brief account is given of visits to Big Room Cave in 1953, 1954, and 1955 and the use of the topographic map in tracing underground stream channels and exploring for new caves. Collapse within a cave may be reflected by the occurrence of a sink hole above the cave collapse, or, perhaps, by stream capture. More general indications of collapse may appear on topographic maps as modifications of "normal" contour lines. --G. E. Denegar.

1-833. Green, Dale J., and William R. Halliday. AMERICA'S DEEPEST CAVE: Natl. Speleol. Soc., Bull. no. 20, p. 31-37, map, Nov. 1958, 19 refs.

Neff Canyon Cave, Utah, is believed to be the deepest cave in the United States; its bottom is 1186 ft. below the entrance. It lies within the middle and lower members of the Middle Cambrian Ophir formation. At the cave entrance, the beds dip 50°N., and strike E.-W. In this area, the middle members of the Ophir formation consist of a moderately thin-bedded gray limestone about 80 ft. deep. The lower member is about 240 ft. thick and consists largely of flakey reddish-brown to dark-brown shale. The main passage is developed along a fault paralleling the dip. The side passages of the upper part of the cave appear to be joint-determined. There is evidence that the basic origin of the cave is the result of phreatic solution.

A popular account of the exploration of this cave is given. --G. E. Denegar.

1-834. Meyers, Arnold. CAVES OF YUCATAN AND GUATEMALA: Natl. Speleol. Soc., Bull. no. 20, p. 51-57, 4 illus., map, Nov. 1958, 4 refs.

Rocks of the Yucatan Peninsula are late Tertiary and Quaternary in age; in Guatemala, there are no rocks younger than Tertiary limestones. The entire hill area of Yucatan abounds with "cenotes" or water caves, while remnants of water caves occur throughout the peninsula. A brief history of cave exploration in Yucatan and a popular account of the author's own explorations in various caves of Yucatan and Guatemala is given. --A. C. Sangree.

1-835. Skřivánek, František. SPELEOLOGY IN CZECHOSLOVAKIA: Natl. Speleol. Soc., Bull. no. 20, p. 41-45, 2 maps, Nov. 1958.

The Czech karst region (western Czechoslovakia) is located in folded Silurian and Devonian limestones near Prague. The Berounka river, which is bordered by extremely well-developed terraces, flows through the center of the region. The largest caverns are those known as Koněprusy. They were discovered in 1950 and are nearly 2 km. long. Other caverns are at Chlum near the township of Srbsko; Barrandova; Nad Kačákem; Ledeč; Chýnov, Sušice-Volyně. Pseudo-karstic caverns are developed in sandstone in northern and eastern Bohemia.

In Moravia (central Czechoslovakia) the largest karstic region is developed in Devonian limestone. Notable caverns include the Sloupsko-Sošůvské, the Punkevní or Macošské, Kateřinská, Býčí Skála, Výpustek, Javoříčské, Zbrašovské, and others, briefly described.

Slovakia (eastern Czechoslovakia) contains the most beautiful caverns in the country - those of Demänova. They are formed in Triassic limestone and are more than 12 km. long. Also briefly described are the ice cave of Dobšinská and the karstic region of Jihoslovenský Kras and some of its more famous caves. Nearly all the caverns were discovered in the period between the two world wars.

Some notes on speleological methods are given. --A. C. Sangree.

1-836. Schworm, Robert E. CAVES OF KWANGSI: Natl. Speleol. Soc., Bull. no. 20, p. 38-40, 7 illus., Nov. 1958.

Caves, varying in size and extent, are abundant in the conical mountains of Kwangsi Province of southern China. Some are small with difficult passages; others are large with interconnecting rooms. The largest room found was about 200 to 300 ft. long and 70 to 80 ft. wide with a ceiling 35 to 40 ft. high. Floors range from fine clay to gravel and slick mud. --G. E. Denegar.

1-837. Schleusener, Richard A., and A. T. Corey. THE ROLE OF HYSTERESIS IN REDUCING EVAPORATION FROM SOILS IN CONTACT WITH A WATER TABLE: Jour. Geophys. Research, v. 64, no. 4, p. 469-75, diag., 6 graphs, Apr. 1959, 6 refs.

Evaporation studies were conducted on 3 soil types in contact with a water table. For conditions of high evaporativity or increased depth to the water table, it was found that evaporation from the soils was not always in proportion to the rate of evaporation from a free-water surface. Under some conditions there was an inverse relation between evaporation from the soils and that from the free-water surface.

Analysis of upward movement of water from a water table in the absence of hysteresis effects does

not provide a satisfactory explanation for this inverse relation.

A capillary-tube model is used to explain qualitatively these results on the basis of reversals of changes in pressure in the soil water. This hysteresis phenomenon is believed to be responsible for reducing evaporation from soils in contact with a water table. --Auth.

1-838. Smith, G. W. THE DETERMINATION OF SOIL MOISTURE UNDER A PERMANENT GRASS COVER: Jour. Geophys. Research, v. 64, no. 4, p. 477-83, 6 graphs, table, Apr. 1959, 18 refs.

Using climatological, soil, and plant data, an attempt has been made to calculate the moisture status of a soil under a permanent grass cover. It has been shown that it is insufficient to use formulas which estimate potential evapotranspiration only, such as those of Thornthwaite, Blaney and Criddle, or Penman. When these methods were modified to account for decreasing evapotranspiration with decreasing soil moisture, better results were obtained. The ratio of actual to potential evapotranspiration has been denoted by the symbol $\overline{F}$. Three different possibilities for the dependence of $\overline{F}$ on soil moisture have been examined. The theoretical figures have been compared with figures obtained by augering over a period of about 22 months.

It is shown, both graphically and statistically, that Thornthwaite's $\overline{F}$ factor theory is more satisfactory than Penman's or Veihmeyer's. When Thornthwaite's method is used, there is no statistically significant difference between moisture deficits based on the Penman, Blaney and Criddle, or Thornthwaite equations for potential transpiration. --Auth.

1-839. Landes, Kenneth K. ILLOGICAL GEOLOGY: GeoTimes, v. 3, no. 6, p. 19, sec., March 1959, 4 refs.

Geologists think nothing of depressing 12 mi. the continent floor on which Gulf Coast sediments have been deposited or of elevating 5 plus mi. the marine limestones of Mount Everest, but when a layer of fresh-water diatoms is found at a depth of more than 2 mi. in the mid-Atlantic, they seek explanations other than vertical movement.

Many geologists also explain submarine canyons as the result of submarine turbidity currents rather than as the result of rivers draining an emergent sea floor. It is obvious that large areas of the sea floor must have sunk vertical distances measurable in miles. Efforts should be made to find the mechanism that produced these sea-level changes. --A. C. Sangree.

3. STRUCTURAL GEOLOGY

See also: Geologic Maps 1-813; Stratigraphy 1-849; Geophysics 1-900; Mineral Deposits 1-982, 1-1014.

1-840. Biot, M. A. THE INFLUENCE OF GRAVITY ON THE FOLDING OF A LAYERED VISCOELASTIC MEDIUM UNDER COMPRESSION: Franklin Inst., Jour., v. 267, no. 3, p. 211-28, 3 diags., 5 graphs, table, March 1959, 10 refs.

The theory of folding of a layered viscoelastic medium under a horizontal compression parallel with the layer, as developed in previous publications, is extended to take into account the influence of gravity. Characteristic features of the folding are evaluated in terms of nondimensional parameters. The influence of gravity appears through a parameter which depends on the relative magnitude of the gravity forces and the horizontal compression. Specific cases discussed are that of a layer on top of a half-space and the layer embedded between 2 half-spaces, with the bottom medium either denser or less dense than the top one. --Auth.

1-841. Beard, C. Noble. QUANTITATIVE STUDY OF COLUMNAR JOINTING: Geol. Soc. America, Bull., v. 70, no. 3, p. 379-81, 2 tables, March 1959, 6 refs.

Wherever columns or joints are caused by shrinkage in tabular igneous rocks during cooling, prisms occur in a variety of geometric forms. Descriptions, diagrams, and illustrations frequently imply that hexagonal prisms predominate in almost all outcrops. Development of perfect or nearly perfect hexagonal columns is, however, dependent on ideal conditions of slow uniform shrinkage of homogeneous material.

In volcanic districts of the United States the writer noticed that columns in ordinary exposures of basalt or similar igneous rock generally consisted largely of pentagons, with some quadrilaterals; hexagons were hard to find. In 1955 various localities in America and Europe were visited to gather data on columnar jointing. At Craters of the Moon and Lewiston, Idaho; Dunsmuir, California; Devil's Tower, Wyoming; and Mount Rodeix, Auvergne, France, dominance of pentagons over hexagons was noted. In Devil's Postpile, eastern California; Giant's Causeway, Northern Ireland; and also at Sydenham near Melbourne, Australia, exceptionally favorable conditions produced more hexagons than any other form. --A. C. Sangree.

1-842. Beloussov, V. V. TYPES OF FOLDING AND THEIR ORIGIN: Internat. Geology Rev., v. 1, no. 2, p. 1-21, 16 figs. incl. cross-secs., diags., Feb. 1959, 46 refs.

It would seem that the data available today leave no room for doubt that all types of folding are to be regarded as phenomena arising from the vertical oscillations of the earth's crust. The most difficult aspect of this conception is to explain the process that leads to the transformation of vertical movements into crumpling. With a view toward clearing up this question, special structural investigations have been undertaken. The principal results may be summed up as follows:

Of great importance in folding is the fact that during vertical movements, the earth's crust often splits up into separate blocks which undergo differential vertical displacement. Folding is the reaction of stratified plastic rocks to differential vertical movements of blocks. There are 3 types of folding to be distinguished on the kinematic basis: block-folding, folding or injection, and folding of general crumbling. --Auth.

1-843. Henderson, G. G. L., and C. D. A. Dahlstrom. FIRST-ORDER NAPPE IN CANADIAN ROCKIES: Am. Assoc. Petroleum Geologists, Bull., v. 43, no. 3, pt. 1, p. 641-53, 6 figs. incl. illus.,

geol. map, March 1959, 11 refs.

This paper describes the geology of part of the Front Ranges in southeastern British Columbia [Fernie area]. A first-order nappe and a folded thrust are illustrated. Field evidence strongly suggests that thrust faulting began and ended during the latter stages of folding. --Auth.

1-844. Higgs, Donald V., and John Handin. EXPERIMENTAL DEFORMATION OF DOLOMITE SINGLE CRYSTALS: Geol. Soc. America, Bull., v. 70, no. 3, p. 245-77, 20 figs. incl. diags., graphs, 6 pls., 9 tables, March 1959, 22 refs.; also pub. as: Shell Devel. Co., Explor. & Production Research Div., Pub. no. 161.

Jacketed cylindrical specimens of dolomite single crystals were deformed dry under a constant confining pressure of 5000 bars at a strain rate of 1 percent per minute at temperatures from 24°C. to 500°C. Uniaxial compression and extension experiments were carried out with the load oriented (1) parallel to the optic axis $\underline{c}_{\nu}$, (2) parallel to a horizontal axis $\underline{a}$, (3) perpendicular to a cleavage $\underline{r}$, and (4) parallel to an edge [$f:f$].

In orientations (1) and (2), unfavorable for basal translation, crystals loaded at temperatures below 400°C. are brittle and fail on shear fractures inclined at about 30° to the direction of greatest principal pressure. At 400°C. and above, specimens of orientations (1) and (2) flow in compression and extension, respectively. Large permanent deformations are achieved in orientations (3) and (4), favorable for translation gliding, at all temperatures.

Petrographic studies by the techniques developed by Turner in his investigation of calcite crystals reveal that translation gliding on $\underline{c}$ {0001} along the gliding line parallel to an a axis is the flow mechanism for orientations (3) and (4) below 400°C. This confirms Johnsen's first discovery and the results of the later work of Turner et al. on dolomite rock. The intracrystalline slip mechanism for orientations (1) and (2) is twin gliding on f {00$\bar{2}$1} in a negative direction sense (in contrast to the positive sense of $\underline{e}$ {01$\bar{1}$2} twinning in calcite), which, however, occurs only at about 400°C. and above. This confirms the hypothesis of Fairbairn and Hawkes and the data of Turner et al. and Handin and Fairbairn for dolomite rocks. In orientations (3) and (4) twinning occurs to the exclusion of translation at 500°C., and both mechanisms are operative at 400°C.

The critical resolved shear stress for translation increases with temperature up to 400°C. at least, a most unusual behavior. The critical stress for twinning decreases at least in the range of 400°C. to 500°C., and the 2 critical stresses are equal at about 400°C.

A few magnesite crystals were deformed parallel to $\underline{c}_{\nu}$ under similar conditions. Basal translation cannot occur in this orientation, but translation on $\underline{r}$ {10$\bar{1}$1} along the line [10$\bar{1}$1:02$\bar{2}$1] does occur. No twinning was detected. --Auth.

1-845. Nikolaev, V. A. SOME STRUCTURAL CHARACTERISTICS OF MOBILE TECTONIC BELTS.[1] Translated by Mark Burgunker: Internat. Geology Rev., v. 1, no. 1, p. 50-64, Jan. 1959, 17 refs.

The present paper is an exposition of the author's views on a series of problems in the structural development of the mobile belts in the earth's crust. The tectonic and facies characteristics by which the fundamental components of the mobile belts - geosynclines and geanticlines - are distinguished, are presented in outline. The laws that govern the evolution of these components in space and time are also indicated. --Auth.

[1]Translated from Akademiya Nauk SSSR, Izvestiya, Seriya Geologicheskaya, 1953, no. 2.

1-846. Kuegelgen, H. v. DER AUFBAU DER ZENTRALEN SIERRA MADRE ORIENTAL, MEXICO [THE STRUCTURE OF THE CENTRAL SIERRA MADRE ORIENTAL, MEXICO]: Deutsche Geol. Gesell., Zeitschr., v. 110, pt. 1, p. 117-40, illus. incl. geol. map, scale 1:100,000, 1958.

The central Sierra Madre Oriental, Hidalgo, Mexico, is an anticlinal structure, trending NNW., with a core of pre-Jurassic crystalline rocks overlapped by transgressive Jurassic and Cretaceous sediments. Tertiary dikes and volcanic masses intrude and cover the sedimentary sequence in places. Unfossiliferous terrestrial clays, sandstones, and conglomerates at the base of the volcanic series are probably early Tertiary in age. They are considered to have been deposited following a period of intense denudation during which much of the Cretaceous was removed. The structure was originally a topographic swell which was incorporated into the Hidalgo anticlinorium and upwarped during the Laramide orogeny. Faulting in the closing stages of the main period of folding produced the channelways for extrusion of older acid and younger basic volcanic material. --M.S.

1-847. Hope, E. R. GEOTECTONICS OF THE ARCTIC OCEAN AND THE GREAT ARCTIC MAGNETIC ANOMALY: Jour. Geophys. Research, v. 64, no. 4, p. 407-27, 5 maps (one fold.), cross-sec., table, Apr. 1959, 51 refs.

A tentative description of the structure of the Arctic Ocean floor is presented in terms of recent data from Soviet sources and of certain representative Soviet theories of Arctic tectonics. Two theories of the great arctic magnetic anomaly are compared: the anomaly may be related either to an interplatform geosynclinal corridor extending across the Arctic Ocean floor or to ancient centers of crustal consolidation in the Canadian and central Siberian platforms. --Auth.

4. STRATIGRAPHY AND HISTORICAL GEOLOGY

See also: Geologic Maps 1-812; Areal and Regional Geology 1-819, 1-826; Paleontology 1-860, 1-869, 1-873; Geophysics 1-885, 1-886; Sedimentary Petrology 1-950; Mineral Deposits 1-1038.

1-848. Zhemchuzhinikov, Y. A. THE PROBLEM OF UNDERSTANDING THE NOMENCLATURE OF FACIES.[1] Translated by Eugene Alexandroff: Internal. Geology Rev., v. 1, no. 1, p. 65-72, Jan. 1959, 17 refs.

Modern geology, with its subdivisions, needs clear and precise definitions. Various geologists have used the term "facies" to denote widely varying stratigraphic

features. Facies have been defined by their lithologic, paleontologic, genetic, paleogeographic, and/or physiogeographic characteristics, resulting in no clear concise interpretation of the author's intentions. The majority of geologists interpret the term as the environment of sedimentation and ecology of organisms. A new, more developed definition is: "Facies reflects the environment of the accumulation of sediments and the formation of a certain layer (bed, horizon). This environment is reconstructed on the basis of the lithological characteristics, paleontological content, geochemical features, and other evidence."--G. E. Denegar.

[1]Translation of: K Voprosu o Ponimanii i Nomenklature Fatsiy: Akademiya Nauk SSSR, Izvestiya, Seriya Geologicheskaya, 1957, no. 2, p. 7-14.

1-849. Green, R. PRECAMBRIAN BASEMENT FEATURES IN NORTHERN ALBERTA: Research Council Alberta, Geol. Div., Bull. 3, 12 p., illus., 2 maps (in pocket), Dec. 1958, 36 refs.

Late Devonian basement topography is reconstructed. Topographic features, in particular the Peace River high, are described, and their tectonic development discussed. The several major topographic features exerted influence on Middle and Late Devonian sedimentation. The discussion is primarily interpretive. The map of Devonian basement topography is basically an inverted isopach map, the isopachs being drawn for the interval between the top of Devonian strata and the Precambrian basement. Reconstruction is based on well data; control is good over and adjacent to the Peace River high, but becomes much poorer northward and northeastward. It is concluded that major pre-Devonian topographic features were primarily structural in origin, and were produced by warping of the late Precambrian erosion surface, not by fault movement. A westward continuation of the Lake Athabasca tectonic trend - a SW.-trending line of structural weakness - is considered more likely to mark the northern boundary of the Peace River high, rather than to pass through the high itself as indicated in most earlier papers.--Auth.

1-850. Armstrong, Augustus K. THE MISSISSIPPIAN OF WEST-CENTRAL NEW MEXICO: New Mexico, Bur. Mines & Mineral Resources, Mem. 5, 35 p., 21 figs., 6 pls., 4 tables, 1958, 36 refs.

Mississippian rocks were studied in detail in the Ladron, Lemitar, and Magdalena mountains, and Coyote Hills, of W.-central New Mexico.

The oldest Mississippian strata in this area belong to the Caloso formation, which contains a small brachipod fauna suggestive of a Kinderhookian or lower Osagian age. The Caloso formation rests on a truncated igneous and metamorphic complex of Precambrian age. The base of the Caloso formation (0 to 8 ft.) consists of intergrading arkoses, sandstone, shales, and limestones. This is followed by about 30 ft. of dark-gray fine-crystalline algal limestone.

The Caloso formation is overlain disconformably by the Kelly formation, which varies from 0 to 70 ft. in thickness and is a light-tan to gray crinoidal limestone that contains a brachiopod and blastoid fauna of upper Osagian (Keokuk) age. The Kelly formation is overlain unconformably by the Sandia formation of Pennsylvanian age in the Lemitar and Magdalena mountains. In the Ladron Mountains, the Kelly and Caloso formations pinch out northward beneath the Sandia unconformity.

The brachiopod, blastoid, and coral fauna of the Kelly and Caloso formations are described and illustrated.--New Mexico Bur. Mines & Mineral Resources.

1-851. Bode, H. DIE FLORISTISCHE GLIEDERUNG DES OBERKARBONS DER VEREINIGTEN STAATEN VON NORDAMERIKA [THE FLORAL SUBDIVISION OF THE UPPER CARBONIFEROUS OF THE UNITED STATES OF NORTH AMERICA]: Deutsche Geol. Gesell., Zeitschr., v. 110, pt. 2, p. 217-59, illus. incl. geol. sketch maps, 1958.

A detailed study of the composition and stratigraphic relations of plant assemblages in upper Carboniferous formations of the United States shows that the floras are essentially identical to upper Carboniferous floras of Europe. The sequence of plant zones in both regions in also essentially identical. The sharp distinction between lower Namurian and younger Carboniferous floras of Europe is not so striking in the United States, but the floras of older and younger Westphalian deposits of both regions are characterized by the same index species. The Pennsylvanian corresponds to a large part of the upper Carboniferous of Europe, but the 2 terms are not synonymous, in that beds equivalent to the Stephanian beds of Europe are absent in the Pennsylvanian sequence of the United States. The upper boundary of the Westphalian corresponds to the Washington formation in the lower part of the Dunkard group; higher beds of the Dunkard group contain a flora which exhibits affinities with the Permo-Carboniferous Cathaysian flora and cannot be correlated with that of the Stephanian beds overlying the Westphalian of Europe.--M.S.

1-852. Hunt, A. D., and J. D. Ratcliffe. TRIASSIC STRATIGRAPHY, PEACE RIVER AREA; ALBERTA AND BRITISH COLUMBIA, CANADA: Am. Assoc. Petroleum Geologists, Bull., v. 43, no. 3, pt. 1, p. 563-89, 15 figs. incl. maps, secs., table, March 1959, 31 refs.

During the past 5 years, through the discovery of significant accumulations of oil and gas, the Triassic formations of the Peace River area have assumed a position of economic importance. The Triassic has been subdivided into 6 formations, Toad-Grayling, Liard, Halfway, Charlie Lake, Baldonnel, and Pardonet, using wherever possible the names assigned by others working in the area. Each formation has been described, and type sections designated for the Halfway, Charlie Lake, and Baldonnel formations. Isopachous maps and, for most of the formations, lithofacies maps have been drawn to show the lateral variations within these formations. Correlation has been established with the outcrop sections of the adjacent Rocky Mountains foothills, together with limited age determinations. The depositional history is reviewed, including a discussion of the evaporitic cycle of the Upper Triassic.--Auth.

1-853. Jeletzky, J. A. UPPERMOST JURASSIC AND CRETACEOUS ROCKS OF AKLAVIK RANGE, NORTHEASTERN RICHARDSON MOUNTAINS, NORTHWEST TERRITORIES: Canada, Geol. Survey, Paper 58-2, 84 p., illus., geol. sketch map & correlation chart (in pocket), 1958, 40 refs.

Present in the Aklavik Range is an unusually thick

and complete section of predominantly marine, uppermost Jurassic and early to mid-Lower Cretaceous shales, siltstones, and sandstones. Except for an apparently brief hiatus between the Jurassic and Cretaceous, the succession seems to be continuous from the Upper Jurassic Portlandian and upper Thithonian stages through the Lower Cretaceous Berriasian stage into the Valanginian. At that point there appears to be an erosional gap of some magnitude. There is evidently considerable overlap as in some places the earlier sedimentary record ceases before the base of the Valanginian stage, whereas in others it is continuous into the base of succeeding Hauterivian.

Sedimentation was resumed at the base of the Barremian and continues through the succeeding Aptian stage. From there up the succession is imperfectly known, but rocks of Albian age (the last stage of the Lower Cretaceous) although unknown are probably present in places. --H. M. A. Rice.

1-854. Glaister, R. Perry. LOWER CRETACEOUS OF SOUTHERN ALBERTA AND ADJOINING AREAS: Am. Assoc. Petroleum Geologists, Bull., v. 43, no. 3, pt. 1, p. 590-640, 12 figs. incl. illus., maps, 6 secs., March 1959, 73 refs.

The total stratigraphic interval studied in southern Alberta and northern Montana includes all of the Lower Cretaceous strata between the sub-Cretaceous unconformity and the base of the "Fish Scale" sandstone, which occurs near the Lower Cretaceous-Upper Cretaceous boundary. Abrupt facies changes in the Lower Cretaceous sediments in western Alberta necessitate a different nomenclature in the Foothills area than in the Plains area.

In the southern Alberta Foothills, the continental sediments of the Blairmore group can be divided into 2 distinct lithologic parts. The lower Blairmore consists dominantly of gray shale and gray to buff protoquartzite-type sandstones and contains 2 members. The Cadomin member at the base of the lower Blairmore is a persistent chert and quartzite pebble conglomerate which can be traced throughout the Alberta Foothills. The "Calcareous" member, consisting of gray to buff argillaceous limestones, calcareous shale, and buff calcareous quartzose sandstone, occurs at the top of the lower Blairmore. The upper Blairmore sediments show a marked change in color and lithologic character from those below. The sediments are dominantly green, and the sandstones are usually highly feldspathic and chloritic arkosic graywackes and lithic graywackes.

The Crowsnest formation overlies the Blairmore group in the southwestern corner of Alberta and is composed of a series of tuffs, agglomerates, breccias, and flows.

In the Plains area, the Lower Cretaceous is divided into 4 major lithologic units, in ascending order: Mannville group, Joli Fou formation, Viking formation, and an unnamed unit above the Viking formation and below the base of the "Fish Scale" sandstone.

The Mannville group is dominantly non-marine but contains some marine strata in central Alberta. The lower Mannville usually contains a basal quartzose sandstone member called the Cut Bank and Sunburst sandstones in southern Alberta, and the Ellerslie sandstone in central Alberta. The top of the lower Mannville is placed at the top of the "Calcareous" member which is correlated lithologically with the "Calcareous" member in the Blairmore group.

The upper Mannville consists of kaolinitic subgraywacke-type sandstones, siltstones, shales, and thin coal beds, and is equivalent to the lower part of the upper Blairmore at the W. In central Alberta, a marine "Glauconitic" sandstone occurs near the base.

The Joli Fou formation is a marine dark-gray shale body at the base of the Colorado group which loses its lithologic identity in western and southern Alberta.

The Viking formation consists of a marine succession of "salt-and-pepper" protoquartzites interbedded with gray siltstones and shales. In southern Alberta, the Viking and Joli Fou formations are not recognizable as 2 distinct units, and the entire succession is called the Bow Island formation, which is correlated with parts of the upper Blairmore and Crowsnest formations in the Foothills area.

An isopach map of the Lower Cretaceous indicates the Alberta Foothills was the site of a marginal basin in Lower Cretaceous time. Petrographic and lithofacies studies suggest the Lower Cretaceous sediments were mainly derived from an orogenic positive area in S.-central British Columbia, with minor contributions from a mildly positive area in northern Saskatchewan and Manitoba. The lithologic character of the lower Blairmore suggests a metasedimentary source area, whereas the arkosic sediments of the upper Blairmore are indicative of an igneous source. The abrupt decrease in the feldspar content of the sandstones eastward, accompanied by an increase in kaolinitic clay matrix, is attributed to physical and chemical processes, and to "dilution" of the western-derived sediments by clastics from an eastern source. --Auth.

1-855. Page, Richard A. THE QUESTIONABLE AGE OF THE AQUIA FORMATION: Jour. Paleontology, v. 33, no. 2, p. 347-50, March 1959, 10 refs.

The Aquia formation, outcropping in a belt across Maryland and Virginia, unconformably overlies the Brightseat formation of lowermost Paleocene age. On the basis of planktonic foraminifera collected at the type locality, the formation had been dated as upper Paleocene. Others had dated the formation as equivalent to the Eocene Wilcox group.

Presence of such Foraminifera as Ceratobulimina perplexa Plummer, Citharina plumoides (Plummer), Robulus midwayensis Plummer, and Bulimina cacumenata Cushman & Parker, together with the evidence of the planktonic species would seem to indicate a Paleocene age for the formation. --A. C. Sangree.

1-856. Mullineaux, D. R., L. M. Gard, and D. R. Crandell. CONTINENTAL SEDIMENTS OF MIOCENE AGE IN PUGET SOUND LOWLAND, WASHINGTON: Am. Assoc. Petroleum Geologists, Bull., v. 43, no. 3, pt. 1, p. 688-96, map, 2 tables, March 1959, 10 refs.

Sediments of late Miocene age along both sides of the southern half of the Cascade Range in Washington contain distinctive hornblende andesite detritus. The lithologic character and fossil flora of these sediments suggest that the Cascade Range did not have its present height in late Miocene time, but that a highland probably existed which shed debris derived from the Keechelus andesitic series. Renewed volcanic activity in this highland provided the hornblende andesite detritus which accumulated locally on both sides of the present range in the form of mudflow and fluvial deposits. --Auth. summ.

1-857. Strain, W. S. BLANCAN MAMMALIAN FAUNA FROM RIO GRANDE VALLEY, HUDSPETH COUNTY, TEXAS: Geol. Soc. America, Bull., v. 70, no. 3, p. 375-77, sec., March 1959, 6 refs.

An early Pleistocene age can now be assigned to part of the basin fill in the Rio Grande valley NE. of McNary in the SE. part of the Hueco Bolson. Previously no precise age was known because of lack of fossils. Bones are very rare, but enough have been found recently to determine the presence of a local fauna of Blancan age.

The lower part (Unit A) of the section of basin fill is composed of red, brown, and gray claystone and siltstone, with some bentonite and gypsum. The preliminary faunal list is: Testudo, Geomys, Nannippus, Sigmodon, Citellus, Scalopus. The upper part of the section (Unit B) lies unconformably on Unit A and is composed of gray sand and brown clayey sand, volcanic ash and silt. The preliminary faunal list is: Equus (Plesippus), Nannippus, Testudo, Tapirus, Megalonyx, Glyptodon. The unfossiliferous part of Unit B is thought to be Pleistocene, early Kansan or older. Unit A could be Pliocene or perhaps an interglacial age in the Pleistocene, probably Aftonian. --A. C. Sangree.

1-858. Goldich, Samuel S., H. Baadsgaard, G. Edwards, and C. E. Weaver. INVESTIGATIONS IN RADIOACTIVITY-DATING OF SEDIMENTS: Am. Assoc. Petroleum Geologists, Bull., v. 43, no. 3, pt. 1, p. 654-62, map, 2 tables, March 1959, 25 refs.

Two samples of glauconite from the Upper Cambrian Franconia formation in Goodhue County, Minnesota, give an average K-Ar age of 440 million years. Illite from the Siyeh limestone, Belt series, Glacier Park, Montana, is dated at 740 million years by K-Ar and 780 million years by Rb-Sr techniques. Pipestone from the Sioux quartzite at Pipestone, Minnesota, gives a K-Ar age of 1.20 billion years, and the time of deposition of the Sioux formation is placed in the early middle Keweenawan or lower Keweenawan. Geologic history of sediments subsequent to deposition is most important in attempting to date the time of deposition. X-ray crystallographic studies coupled with radioactivity-dating should lead to a better understanding of the history of sediments and of the changes that commonly are attributed to diagenesis. --Auth.

5. PALEONTOLOGY

See also: Stratigraphy 1-850, 1-851, 1-855, 1-857; Sedimentary Petrology 1-950.

1-859. Jeffords, Russell M., and Daniel H. Jones. PREPARATION OF SLIDES FOR SPORES AND OTHER MICROFOSSILS: Jour. Paleontology, v. 33, no. 2, p. 344-47, fig., March, 1959, 7 refs.

The preparation of plant and other acid-insoluble microfossils for microscope study commonly involves the mounting of chemically processed residues on glass slides. Mounting media more commonly comprise a single layer of Canada balsam, diaphane, glycerin jelly, or other material mixed with the residue between the slide and the cover slip. These may discolor, may be too fragile, or may result in the occurrence of specimens at many different levels

"Cellosize," a powdered hydroxyethyl cellulose (HEC), used in two-layered mounting, acts both as a dispersing agent and as a thin film-former which adheres firmly to both glass and plastic. HEC is water soluble so that aqueous residues do not need to be dehydrated. Several varieties are available for obtaining a range from low to high viscosity. HEC is reported to be clear, colorless, and insensitive to light.

Basic phases in the maceration process of samples to obtain microfloras and associated acid-insoluble microfossils are described. --G. E. Denegar.

1-860. Hill, Dorothy. SOME ORDOVICIAN CORALS FROM NEW MEXICO, ARIZONA, AND TEXAS: New Mexico, Bur. Mines & Mineral Resources, Bull. 64, 25 p., 2 pls., 1959, 32 refs.

Poorly preserved corals of the genera Palaeophyllum, Streptelasma?, Nyctopora, Calapoecia, Paleofavosites, and Reuschia are described from the Upham, Aleman, and Cutter formations. Figures of thin sections of the holotype of Columnaria thomi Hall are given. Collection localities were the Clifton-Morenci area (southeastern Arizona), Mud Springs Mountains (S.-central New Mexico), and McKelligon Canyon (Franklin Mountains, near El Paso, Texas).

The present paper gives the first indication that a remnant of the Montoya group is preserved in the Clifton-Morenci region of Arizona, where it had not been differentiated previously from the Longfellow limestone. --F. E. Kottlowski and R. H. Flower.

Preface by Rousseau H. Flower.

1-861. Perry, T. G., and R. C. Gutschick. BRYOZOANS FROM THE AMSDEN FORMATION, SOUTHWEST MONTANA: Jour. Paleontology, v. 33, no. 2, p. 313-22, 3 pls., March 1959, 15 refs.

Nine new species of bryozoans belonging to the orders Cyclostomata and Trepostomata are described from exposures of the Amsden formation in Madison and Jefferson counties, southwestern Montana. Four species are assigned to the cyclostomatous genera Fistulipora, Cyclotrypa, and Dybowskiella, and 5 species to the trepostomatous genera Tabulipora and Stenophragmidium. The range of Stenophragmidium, which apparently has not been hitherto recognized in North America, is extended to include its occurrence in strata of probable Pennsylvanian age. --Auth.

1-862. Ager, D. V. THE CLASSIFICATION OF THE MESOZOIC RHYNCHONELLOIDEA: Jour. Paleontology, v. 33, no. 2, p. 324-32, 4 figs., pl., March 1959, 22 refs.

The various families which have been proposed for Mesozoic rhynchonelloids are re-examined. The family Dimerellidae is revised, and a new family and genus are proposed for the remarkable Rhaetic brachiopod "Rhynchonella" cornigera (Schafhäutl). Internal details are given for this species and for Sulcirostra seguenzae (Gemmellaro) of the Dimerellidae. Three new subfamilies are proposed within the Dimerellidae. --Auth.

1-863. Sweet, Walter C. MUSCLE-ATTACHMENT IMPRESSIONS IN SOME PALEOZOIC NAUTILOID CEPHALOPODS: Jour. Paleontology, v. 33, no. 2, p. 293-304, fig., 2 pls., March 1959, 40 refs.

Muscle-attachment impressions are described for the first time from representatives of the nautiloid suborders Oncoceratina (Oncoceras sp., Beloitoceras sp., Diestoceras sp.) Ascoceratina (Billingsites deformis (Eichwald)?), Discosorina (Parryoceras euchari Sweet & Miller), and Rutoceratina (Metacoceras sp.). Notes concerning the probable configuration of such impressions in certain Paleozoic Barrandeoceratina (Charactoceras?) and Triassic Lyroceratina (Proclydonautilus ursensis Smith) are included. Muscle-attachment impressions are not known in the Endoceratina and Actinoceratina; in known Ellesmeroceratina, Michelinoceratina, and secondarily straight Tarphyceratina (Lituitidae) the retractors were attached dorsally ("dorsomyarian"), whereas in described Barrandeoceratina, coiled Tarphyceratina, Ascoceratina, Oncoceratina, and Discosorina, these muscles were attached ventrally ("ventromyarian"). Described Rutoceratina, Nautilina, Solenochilina, and Lyroceratina are similar in that the retractors were attached laterally ("pleuromyarian"). In several cases, similar attachment patterns suggest adaptive convergence, rather than relationship, and their taxonomic significance is thereby reduced. --Auth.

1-864. Kjellesvig-Waering, Erik N. A TAXONOMIC REVIEW OF SOME LATE PALEOZOIC EURYPTERIDA: Jour. Paleontology, v. 33, no. 2, p. 251-56, pl., March 1959, 19 refs.

The type species of Mycterops Cope, 1886, (M. ordinatus Cope) is redescribed and refigured inasmuch as the original description and figures were inaccurate. The family Mycteropidae Cope, 1886, is emended to include only the genus Mycterops and is referred to the superfamily Eurypteracea Burmeister, 1845. Mycterops? scabrosus Woodward, previously included in the family Mycteropidae, is considered the genotype of a new genus, Woodwardopterus, which is referred to a new family, Woodwardopteridae, and delegated to the superfamily Stylonuracea Diener, 1924. Campylocephalus scouleri (Hibbert), hitherto mainly included in the family Stylonuridae Diener, 1924, is made the type species of a new genus, Hibbertopterus, which is included along with the genus Campylocephalus Eichwald, 1860, in a new family, Hibbertopteridae, and referred to the superfamily Stylonuracea Diener, 1924. --Auth.

1-865. Ezra, H. C., and S. F. Cook. HISTOLOGY OF MAMMOTH BONE: Science, v. 129, no. 3347, p. 465-66, photomicrograph, Feb. 20, 1959, 3 refs.

Compact bone from a frozen Alaskan mammoth was examined histologically and chemically to determine whether there had been any detectable alterations since the death of the animal. Histological sections closely resembled similar specimens from modern elephants. Total N and acid-extractable carbonate were at levels to be expected in fresh bone. --Auth.

1-866. Gutschick, Raymond C., and John F. Treckman. ARENACEOUS FORAMINIFERA FROM THE ROCKFORD LIMESTONE OF NORTHERN INDIANA: Jour. Paleontology, v. 33, no. 2, p. 229-50, 3 figs., 5 pls., March 1959, 32 refs.

Several thousand arenaceous Foraminifera have been obtained from insoluble residues of Mississippian Kinderhook Rockford limestone collected from 2 localities in Jasper and Benton counties, Indiana. Fourteen or more genera and 33 species, 22 of which are new, represent the families Astrorhizidae, Saccamminidae, Hyperamminidae, Reophacidae, Tolypamminidae (includes ammodiscids), and Lituolidae. Distribution of forms is divided between those with affinities to older Silurian and Devonian faunas, and others, in greater number, with affinities to the younger Pennsylvanian arenaceous Foraminifera. No other systematic studies of arenaceous Foraminifera are available of Kinderhook faunas of the United States on which to base a paleontologic comparison. --Auth.

1-867. Bhatia, S. B., and S. K. Singh. CARBONIFEROUS (URALIAN) FORAMINIFERA FROM MANENDRAGARH, CENTRAL INDIA: Micropaleontology, v. 5, no. 1, p. 127-34, 2 pls., table, Jan. 1959, 23 refs.

The first known occurrence of foraminifera in the Upper Carboniferous marine bed near Manendragarh, central India, is reported. Nine species are recorded, including one new species. The fauna is characterized by the exclusive occurrence of arenaceous forms, which show affinity with contemporaneous faunas from the Pennsylvanian of North America. --Auth.

1-868. Maync, Wolf. THE FORAMINIFERAL GENERA SPIROCYCLINA AND IBERINA: Micropaleontology, v. 5, no. 1, p. 33-68, 3 figs., 8 pls., Jan. 1959, 60 refs.

The duly designated genotype Spirocyclina choffati Munier-Chalmas, 1887, from the Senonian of Les Martigues, southern France, has never been figured to date, so that the genus Spirocyclina has been repeatedly misinterpreted and is still not definitely known. With regard to its internal organization, Spirocyclina choffati from the Senonian of the Marseille region differs from the other forms of "Spirocyclina" of authors recorded from the Upper Jurassic and Lower Cretaceous; the generic name Iberina Munier-Chalmas, 1902, is therefore reinstated for the tests described first by Choffat from Portugal and subsequently by numerous authors from many other parts of the Tethys domain. --Auth.

1-869. Bolli, Hans M. PLANKTONIC FORAMINIFERA FROM THE CRETACEOUS OF TRINIDAD, B.W.I.: Bulls. Am. Paleontology, v. 39, no. 179, p. 257-77, 4 pls., chart, Apr. 1959, 8 refs.

Thirty-three species and subspecies of planktonic Foraminifera from the Lower and Upper Cretaceous of Trinidad are described or listed and their stratigraphic ranges shown on a table. The following species are described as new: Planomalina blowi, P. maridalensis, P. saundersi, Praeglobotruncana crassa, P. modesta, P. rohri, and Globigerina kugleri. While the zonation of the Upper Cretaceous formations remains unchanged, 5 foraminiferal zones are proposed for the still incompletely known Lower Cretaceous Toco, Cuche, and Maridale formations. --Auth.

1-870. Zalesny, Emil R. FORAMINIFERAL ECOLOGY OF SANTA MONICA BAY, CALIFORNIA: Micropaleontology, v. 5, no. 1, p. 101-26, 21 figs. incl. maps, secs., graphs, pl., table, Jan. 1959, 27 refs.; also pub. as: Los Angeles, Univ. Southern California, Allan Hancock Found. Sci. Research, Contr. no. 225.

Bottom samples from shallow to deep water were collected in Santa Monica Bay, California. The distributions of both living and dead foraminifera were determined. The majority of species living in the bay were found to have sharply restricted geographic and bathymetric ranges. Environmental factors such as current, nutrients, salinity, bottom sediments, and especially temperature are believed to control the distribution patterns of the benthonic species in the bay. The paleontological and oceanographic applications of this work are discussed, and 4 new forms are described. --Auth.

1-871. Parker, Frances L., and William D. Athearn. ECOLOGY OF MARSH FORAMINIFERA IN POPONESSET BAY, MASSACHUSETTS: Jour. Paleontology, v. 33, no. 2, p. 333-43, map, 4 graphs, pl., March 1959, 9 refs.

Distributions of the species of Foraminifera (living and dead) forming the greater part of the foraminiferal faunas in marshes in Poponesset Bay, Massachusetts, have been studied. Eight stations were sampled bimonthly for one year (Aug. 1956 to Sept. 1957). The marsh environments vary from almost non-marine (with tidal influence) to near marine. Arenoparrela mexicana, Haplophragmoides hancocki, Tiphotrocha comprimata, and Trochammina macrescens decrease with increasingly marine conditions, whereas Jadammina polystoma and Trochammina inflata increase. Other species such as Ammobaculites dilatatus, Ammotium salsum, Miliammina fusca, and Protelphidium tisburyense fluctuate independently of the degree of brackish or marine conditions. Unknown factors governing micro- and macroenvironments probably play an important part in controlling distributions. Suggested factors are type of vegetation, chemical factors, pH, nutrients, and food. Calcareous specimens are rapidly destroyed after death presumably due either to the ability of the living form to resist acidity or to a postulated increase in acidity immediately below the sediment surface, more probably the latter. This destruction of the tests is of importance in the interpretation of ancient marsh environments. Many species, including the calcareous ones, had their largest living populations in June or Sept. and their smallest in Dec. or Feb. There were some exceptions such as Miliammina fusca which showed an increase in winter. The total living populations were greatest in June and lowest in Dec., which may be related to maximum temperature and time of greatest reduction in temperature respectively. Multiple sampling showed that distributions at any one station were fairly uniform although nearby samples in different microenvironments in some cases vary considerably. --Auth.

1-872. Bé, Allan W. H. ECOLOGY OF RECENT PLANKTONIC FORAMINIFERA: PART I - AREAL DISTRIBUTION IN THE WESTERN NORTH ATLANTIC: Micropaleontology, v. 5, no. 1, p. 77-100, 52 figs. incl. maps, graphs, 2 pls., 2 tables, Jan. 1959, 44 refs.; also pub. as: Columbia Univ., Lamont Geol. Observatory, Contr. no. 307.

Modern planktonic foraminiferal assemblages from quantitative plankton samples collected in the western North Atlantic reflect broad ecologic zones. The relative abundance of 8 species increases southward to the Sargasso Sea, whereas that of 5 other species increases northward to the colder slope waters. The greatest absolute abundance of planktonic foraminifera is in the Gulf Stream system, where strong temperature and salinity gradients exist. --Auth.

1-873. Ethington, R. L. CONODONTS OF THE ORDOVICIAN GALENA FORMATION: Jour. Paleontology, v. 33, no. 2, p. 257-92, 2 figs., 3 pls., 2 tables, March 1959, 66 refs.

Conodonts obtained from acid residues of the Galena formation in Iowa and Minnesota are described. The long-standing question of the correlation of this unit still exists, but the new fauna recovered from the 3 members of the Galena provides additional criteria for age determination. The conodont fauna consists of 48 species which are referred to 26 genera. Three of these genera, Coelocerodontus, Goniodontus, and Rhynchognathus, are new. Belodina is proposed for species formerly assigned to Belodus. Panderodus is established for forms previously placed in Paltodus. Well-preserved conodonts are abundant in the limestone facies of the Galena, whereas they are rare and poorly preserved in the dolomite facies of that formation. Conodonts from the lower Prosser represent a continuation of the underlying Decorah fauna and are very similar to the conodonts of the Kimmswick of northern Missouri and the lower Viola of Oklahoma. A probable late Mohawkian age for these strata is indicated. Faunal elements introduced in the upper Stewartville and Dubuque suggest an early Upper Ordovician age for these beds. Detailed correlation of the members of the Galena formation with the standard Ordovician section in eastern United States cannot be accomplished at this time owing to incomplete knowledge of the faunas of the type Trenton and Cincinnatian. --Auth.

1-874. Stone, G. L., and W. M. Furnish. BIGHORN CONODONTS FROM WYOMING: Jour. Paleontology, v. 33, no. 2, p. 211-28, fig., 2 pls., table, March 1959, 47 refs.

A considerable variety of conodonts has been recovered from 2 shale outcrops within the upper Bighorn dolomite in N.-central Wyoming. A total of 29 species referable to 19 genera is described and illustrated. One new genus, Pristognathus (type: P. bighornensis, n. sp.) and 4 additional new species: Belodina dartoni, B. kirki, Eoligonodina ulrichi, and Microcoelodus sweeti are included in the fauna. The associated megafauna is definitely Late Ordovician, but comparison of the conodonts with others of similar age suggests that they may be pre-Richmondian. --Auth.

1-875. Clark, David L. CONODONTS FROM THE TRIASSIC OF NEVADA AND UTAH: Jour. Paleontology, v. 33, no. 2, p. 305-12, fig., 2 pls., March 1959, 21 refs.

Triassic conodonts have been found in limestone sections from the Wasatch Mountains of N.-central Utah to ranges in E.-central Nevada. Although the

largest concentrations of conodonts are in the Meekoceras ammonoid zone, certain species range several hundred feet above and below this time marker. Two new genera, Parachirognathus and Furnishius, and new species of Gondolella, Prioniodina, and Hindeodella are described. --Auth.

1-876. Kornicker, Louis S. DISTRIBUTION OF THE OSTRACODE SUBORDER CLADOCOPA, AND A NEW SPECIES FROM THE BAHAMAS: Micropaleontology, v. 5, no. 1, p. 69-75, 3 figs. incl. map, Jan. 1959, 62 refs.; also pub. as: Columbia Univ., Lamont Geol. Observatory, Contr. no. 309; Lamont Biology Program, Contr. no. 22.

The suborder Cladocopa comprises 3 genera and about 41 living species, which are worldwide in distribution. Most Recent species are limited to the coastal waters of northwestern Europe and the Mediterranean Sea. Fossil occurrences are limited to Europe, with the exception of 4 specimens found near the top of a North Atlantic sediment core. Large forms from the Paleozoic of Europe are referable to the family Leperditellidae rather than to the Cladocopa. Recent Cladocopa are found exclusively in waters of normal salinity, and seem to prefer water temperatures between 4° and 14°C. Although collected occasionally at depths of 1280 to 2600 m., they are usually found in waters less than 500 m. deep. The geologic evidence indicates that the anterior shell concavity was a late acquisition and may be an adaptation permitting more efficient swimming. If so, this may enable the Cladocopa to complete more successfully, and thus may account for the relatively large number of Cladocopa existing at the present time. A new species of the genus Polycope from the Great Bahama Bank is described and figured. Important papers concerning Recent Cladocopa are included in the bibliography. --Auth.

1-877. Chaloner, W. G. DEVONIAN MEGASPORES FROM ARCTIC CANADA: Palaeontology, London, v. 1, pt. 4, p. 321-32, illus., 1959.

A megaspore assemblage is described from coal and shale deposits of Upper Devonian age from Ellesmere Island, Arctic Canada. All are new species, and 2 represent new genera: Biharisporites ellesmerensis sp. nov., B. ocksensis sp. nov., Triangulatisporites rootsii sp. nov., Lagenicula devonica sp. nov., Ocksisporites maclarenii gen. et sp. nov., and Nikitinsporites canadensis gen. et sp. nov. All but one of these forms are appreciably smaller than typical Carboniferous megaspores. There appears to be a general rise in the mean size of megaspores from the Devonian to the Carboniferous, followed by a diminution in size through the Mesozoic. This may be correlated with the corresponding rise and decline of the arborescent lycopods. --Auth.

1-878. Muller, Jan. PALYNOLOGY OF RECENT ORINOCO DELTA AND SHELF SEDIMENTS: REPORTS OF THE ORINOCO SHELF EXPEDITION; VOLUME 5: Micropaleontology, v. 5, no. 1, p. 1-32, pl., 23 maps, 2 diags. (1 fold.), fold. table, Jan. 1959, 15 refs.

Palynological study of Recent Orinoco [Venezuela] sediments shows the relative influence of location of source area and transport by air and water currents on pollen dispersal. Distribution of fungi, cuticles, reworked material, Hystrichosphaeridae, and foraminifera have also been studied. Variations in microfossil content with depth in core samples are found to be related to depositional history. The significance of the results in palynological and paleogeographical studies of older sediments is discussed. --Auth.

6. GEOPHYSICS

See also: Structural Geology 1-847; Geochemistry 1-911; Mineral Deposits 1-971, 1-1034; Fuels 1-1049.

1-879. Wilson, J. Tuzo. GEOPHYSICAL INSTITUTES OF THE U.S.S.R. AND OF THE PEOPLE'S REPUBLIC OF CHINA: Am. Geophys. Union, Trans., v. 40, no. 1, p. 3-24, 2 tables, March 1959.

Part 1. U.S.S.R., lists the institutes and other bodies dealing with geophysics and related subjects under the direction of the Academy of Sciences, U.S.S.R., and the Dept. of Science of the Ministry of Geology. Also noted are the Arctic Institute, Leningrad; the Dept. of Geophysics, University of Moscow; Institute of Geophysics, Academy of Sciences of Georgia. Those visited are described in some detail. Their organization, history, personnel, accounts of some past and present activities, purpose and proposed investigations are outlined. Observations on laboratories, training, libraries, and museums are noted.

Part 2. China, lists and describes the institutes of the Academia Sinica and the universities of the People's Republic of China; also the Institute of Geological Prospecting under the Ministry of Geology. --G. E. Denegar.

1-880. Howell, B. F., Jr. INTRODUCTION TO GEOPHYSICS: 399 p., 206 figs., fold. map, New York, McGraw-Hill Book Co., Inc., 1959, refs.

A beginning college textbook, this work covers the geophysics of the solid part of the earth. Its principal objectives are to familiarize the reader with the scope of geophysics, to give some insight into the basic principles of the methods by which geophysicists study the earth, and to outline the present state of knowledge of the earth's interior. Prospecting geophysics is not directly discussed, but the fundamental principles of prospecting methods are covered in that they also are basic to more general geophysical studies.

The book is at the level of college juniors, seniors and beginning graduate students. It presupposes familiarity with the terminologies of geology, physics, and chemistry. Elementary calculus is used where it contributes to greater clarity. In the few places where intermediate calculus is used in proofs, these sections are inserted in such a manner that they can be skipped by students with limited mathematical background without missing essential information.

The book is abundantly referenced to lead the student to more comprehensive reference works and important recent and classical papers. An extensive index is provided for those using the book as a reference work.

After a brief discussion of the origin of the earth and moon, successive chapters treat age determinations, temperature and heat of the earth, earthquake seismology, layering and density of the earth, mass, moment, shape and size of the earth, gravity and isostasy, deformation of rocks, origin of the continents, continental drift, tectonic patterns, origin of mountain ranges, geomagnetism, and earth electricity. --Auth.

1-881. Mason, R. G. A MAGNETIC SURVEY OFF THE WEST COAST OF THE UNITED STATES BETWEEN LATITUDES 32° AND 36°N., LONGITUDES 121° AND 128°W.: Geophys. Jour., London, v. 1, no. 4, p. 320-29, illus. incl. map, Dec. 1958.

A total magnetic intensity map covering the area between latitudes 32° and 36°N. and longitudes 121° and 128°W. is presented. It shows a series of narrow anomalies of about 400 γ amplitude trending N.-S. for 300 mi. over a substantially flat abyssal plain. Some possible interpretations are discussed. The anomalies arise at shallow depths beneath the ocean bottom and are consistent with the presence of relatively thin layers of magnetized material overlying a less magnetic crust; they could equally well arise from topography of the upper surface of a continuous magnetic basement for the most part concealed by an overlying blanket of sediments.

The anomalies are intersected by the Murray fracture zone, which interrupts their pattern in such a way as to suggest a right lateral displacement of about 84 nautical mi. --Auth.

1-882. Schufle, J. A. CATION EXCHANGE AND INDUCED ELECTRICAL POLARIZATION: Geophysics, v. 24, no. 1, p. 164-66, 1959.

The mechanism proposed by Vacquier for induced electrical polarization (I.P.) has been tested by measuring I.P. experimentally in the presence of different cations. The results show a decrease in I.P. with increase in valence of the cation for the highest concentration used (0.005 normal), as predicted from the cation-exchange mechanism. As concentration decreases, the I.P. values for sodium, calcium, and lanthanum nitrites appear to approach a common value of about 560 millivolt-seconds per volt; the value for thorium nitrite however remains low even at lowest concentrations. These experiments give some support to the cation-exchange mechanism for the I.P., but the inconsistencies in the results suggest that other factors may be involved. --D.B. Vitaliano (courtesy Geophysical Abstracts, 176).

1-883. Baldwin, Robert W. A DECADE OF DEVELOPMENT IN OVERVOLTAGE SURVEYING: Mining Engineering, v. 11, no. 3, p. 307-14, illus., 2 maps, 11 graphs, diags., March 1959, 16 refs.

Overvoltage, as applied to geophysical exploration, is the phenomenon whereby a current into the earth sets up secondary voltages which decay when the current is interrupted. These secondary effects may be measured with the aid of pick-up electrodes. The term induced polarization has been frequently employed to describe this same phenomenon. In its own operations, Newmont Exploration Ltd. commonly uses the word pulse.

The basis of overvoltage or induced-polarization method as a prospecting device is that metallic particles, in particular sulfides, give a high response, whereas barren rock, with certain exceptions, gives a low response. The overvoltage method has been tried in the search for a number of types of mineral occurrence, but has found its most useful application in outlining widespread disseminated mineralization such as associated with porphyry coppers. --Auth.

1-884. Kisslinger, Carl. OBSERVATIONS OF THE DEVELOPMENT OF RAYLEIGH-TYPE WAVES IN THE VICINITY OF SMALL EXPLOSIONS: Jour. Geophys. Research, v. 64, no. 4, p. 429-36, 6 figs., Apr. 1959, 7 refs.

Study of the particle motion and dispersive properties of waves generated by small explosions has led to the identification of the fundamental M_2 mode and possible a higher mode of this branch of the solution of the Rayleigh wave equation. In the particular field models, consisting of loess and clay over limestone, variations in near-surface conditions at the source have a greater effect on the recorded motion than do similar variations at the recording sites.

The features within the complex motion close to the source can be identified with specific wave types, which are well-separated at the larger distances. --Auth.

1-885. Ewing, Maurice, and Frank Press. DETERMINATION OF CRUSTAL STRUCTURE FROM PHASE VELOCITY OF RAYLEIGH WAVES. PART III: THE UNITED STATES: Geol. Soc. America, Bull., v. 70, no. 3, p. 229-44, 11 figs. incl. 2 maps, sec., graphs, 3 tables, March 1959, 12 refs.; also pub. as: Columbia Univ., Lamont Geol. Observatory, Contr. no. 238; California Inst. Technology, Div. Geol. Sci., Contr. no. 874.

Variations in phase velocity of Rayleigh waves from the Samoa earthquake of Apr. 14, 1957 are reported for the United States. These variations are correlated with topography and Bouguer gravity anomaly on a continental scale, demonstrating regional isostatic compensation. The correlation of phase-velocity variations with crustal-thickness changes is justified, and permits specification of the mechanism of compensation as the regional Airy system.

Regional average crustal thicknesses are: Peninsular Ranges and Southwestern Desert, 40 km; Basin and Range province, 48 km.; Rocky Mountains, 47 km.; Interior Plains, 35-41 km.; Appalachian Mountains, 40 km. --Auth.

1-886. Ewing, John, and Maurice Ewing. SEISMIC-REFRACTION MEASUREMENTS IN THE ATLANTIC OCEAN BASINS, IN THE MEDITERRANEAN SEA, ON THE MID-ATLANTIC RIDGE, AND IN THE NORWEGIAN SEA: Geol. Soc. America, Bull., v. 70, no. 3, p. 291-317, map, 7 secs., 5 fold. pls. (graphs), table, March 1959, 45 refs.; also pub. as: Columbia Univ., Lamont Geol. Observatory, Contr. no. 327.

Seismic-refraction measurements in the western basins of the North Atlantic Ocean show that an average crustal section consists of 1/2-1 km. of low-velocity sediments and 4-6 km. of oceanic crustal rock in which the seismic velocity is about 6.5 km./sec. There is good evidence from sub-bottom reflections and shear waves that in many places there is a layer with a velocity between 4.5 and 5.5 km./sec. and a thickness of 1-2 km. between the low-velocity sediments and the 6.5 km./sec. layer, al-

though it is not usually detected by refracted arrivals. These layers are underlain by the mantle which has an average seismic velocity near 8 km./sec. Measurements in the eastern basins show a similar crustal section, but the velocity below the deep discontinuity appears to be lower (7.7-7.8 km./sec.).

Measurements in the Mediterranean Sea show only low-velocity sediments underlain by a refracting layer in which the average velocity is about 4.5 km./sec.

On the Mid-Atlantic Ridge the sediments are underlain by 2 refracting layers with velocities averaging 5.6 and 7.4 km./sec. respectively. The results indicate that the ridge has been built by the upwelling of great amounts of basalt magma along a tensional fracture zone. Presumably the extensional forces and the supply of basalt magma come from convection currents deep in the mantle. Measurements in the Norwegian and Greenland seas show results very similar to those on the Mid-Atlantic Ridge, and, from this and the extension of the belt of active seismicity, it appears that the ridge structure continued through the Norwegian and Greenland seas into the Arctic Ocean.

The results of a few stations on the continental shelf of North America, Britain, and Norway are presented and compared with previously published results in these areas. --Auth.

1-887. Press, Frank, and Gilbert Dewart. EXTENT OF THE ANTARCTIC CONTINENT: Science, v. 129, no. 3347, p. 462-63, map, 2 graphs, Feb. 20, 1959, 3 refs.

Group velocities of earthquake-generated Love and Rayleigh waves for certain transantarctic paths are abnormally high when compared with data from other continents. For these paths, the data indicate that at most only three-fourths of the Antarctic ice sheet is underlain by continent, the remaining area being oceanic in structure. --Auth.

1-888. Vaughn, W. W., V. C. Rhoden, E. E. Wilson, and Henry Faul. SCINTILLATION COUNTERS FOR GEOLOGIC USE: U. S. Geol. Survey, Bull. 1052-F, p. 213-40, 15 illus., March 1959, 17 refs.

A small light hand-portable scintillation counter, an airborne-carborne scintillation counter, and a portable scintillation gamma-ray well-logging instrument have been designed, constructed, and tested, and are now commercially manufactured. The amplifier circuits take full advantage of the high counting rate that can be obtained from photomultipliers and phosphors. Relaxation-oscillator-type high-voltage supplies provide regulated voltages for the photomultiplier tubes.

The portable-hand scintillation counter was designed to be carried when prospecting on foot. The airborne-carborne unit is primarily intended for broad-area reconnaissance from automobiles or light aircraft at altitudes of 500 ft. or less. This instrument uses a sodium iodide crystal 3 in. in diameter and 1 1/2 in. thick and a photomultiplier tube with a cathode diameter of 3 in. Larger crystals may be adapted. Variations in the geometry of the measurement (mass effect), and the degree of radioactive equilibrium of an exposed surface make it impossible to calibrate the instruments directly in terms of uranium content. However, the instrument can be calibrated in milliroentgens per hour if the type of radiation is specified.

The portable scintillation gamma-ray well-logging instrument has a manually operated reel and is capable of logging holes 1,000 ft. deep. The probe contains only the photomultiplier tube and matching circuit. The energy resolution of the instrument using a cesium source is approximately 10%, measured through the 1,000 ft. of coaxial cable. The portable scintillation gamma-ray well-logging instrument was designed for dual application - as an aid in stratigraphic studies and to log ore-grade material. The wide range of sensitivity is accomplished by adjustments made at the surface. A sample calibration chart for determining the grade of material in a drill hole is included with the report. --Auth.

1-889. Bulashevich, Yu. P. THE GAMMA-EMANATION METHOD OF CLASSIFICATION [SIC] ANOMALIES IN RADIOACTIVITY: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 825-29, graph, 5 tables, Geneva, United Nations, 1958, 7 refs.

By measuring the concentration of emanation and gamma-intensity, it is possible to determine the relative factor of emanation leakage when rocks are in natural occurrences. Theoretical analysis permits selection of the proper conditions of measurement. The soil-air sampling and determination of gamma-intensity should be made at a depth exceeding the diffusion length. Quantitative interpretation of gamma-measurements requires the knowledge of the conversion coefficients whose value depends on the spectral characteristic of the counters and the composition of radiation.

When radioactive elements are distributed unevenly and the spatial distribution of emanation concentration and gamma-intensity are insufficiently correlated, the relative coefficient of emanation leakage is determined by the mean values received.

Observations have shown that the relative coefficient of emanation leakage is a stable parameter which defines various types of rocks.

Emanation anomalies are, as a rule, classified only by their radon or thoron nature. The value of the emanation leakage coefficient allows specification of this classification and isolation of the following types of anomalies: those of content, of emanation leakage, and of gas halos. Apart from this, the evaluation of the emanation leakage of rocks in natural occurrence provides supplementary information on the material, mineral carriers of activity, as high emanation leakage is generally typical for finely-dispersed colloidal forms of occurrence of radioactive elements. --Auth. (transl.).

1-890. Karim, S. M., F. Barendregt, and S. Siraj Ahmad. DETERMINATION OF RADIOACTIVITY OF SOIL AT DIFFERENT DEPTHS: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 830-34, diag., graph, 5 tables, Geneva, United Nations, 1958, 9 refs.

During the boring of a well in search of oil at Drigh Road, Karachi [Pakistan], flushings were collected at every 100 ft. The well was dug to a maximum depth of nearly 10,000 ft. The samples were finely ground to a definite mesh size, their apparent density was determined, and they were put in a special receptacle of an ionization chamber, which was connected to a sensitive electrometer.

The measurements of the ionizing current were made against the ionizing current produced by a standard source.

The results obtained show considerable variation of radioactivity at different depths. Below a depth of 5,000 ft., the value of the relative density remains within a range of about 1.196 and 1.040. This shows stabilization of the active materials. Table shows values of apparent density of the flushings from 200-8900 ft. --From auth. abs.

1-891. Hügi, Th., and F. de Quervain. RESULTS OF THE MEASUREMENT OF RADIOACTIVITY OF ROCKS IN THE HYDROELECTRIC FACILITY TUNNELS: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 835-36, table, Geneva, United Nations, 1958.

In Switzerland, especially in the crystalline areas in the Alps, numerous hydroelectric power stations are at present under construction. These offer possibilities for the systematic measurement of radioactivity in geological profiles in many hundreds of kilometers of gallery such as are seldom to be found exposed on the surface in the same region. The initial program of the [Commission pour la recherche en Suisse de minéraux et de roches à éléments radioactifs et rares was the surveying of these galleries with the scintillation counter. In general, readings of the radiation intensity, gamma [measurements], were taken every 10 m. in the galleries and, where there was variation in the rock type, at shorter intervals. To date it has been possible to produce extensive records from the following important geological units of the Alps: the Aar and Gotthard massifs, the Pennine region, the Bergell massif, and also in various Mesozoic and Tertiary sedimentary regions.

The results of these measurements, carried out under effectively similar conditions, permit very detailed differentiation of rock series or petrographical types. In addition, previously unknown enrichments in U-bearing minerals were found in certain series, in some cases as actual ore horizons. The metamorphic Permo-Carboniferous rocks in the Pennine zone of the Valais proved especially interesting.

The measurements in the galleries will be supplemented by precise radiometric or, in certain cases, chemical analyses. The opportunity will be made use of to examine the specimens collected for further trace elements which can be dealt with spectrometrically. --Auth.

1-892. Smyslov, A. A. RADIOACTIVE ELEMENTS IN IGNEOUS ROCKS OF NORTHERN KAZAKHSTAN: Geochemistry [Geokhimiya], 1958, no. 3, p. 248-58, 4 figs., 4 tables, 13 refs.

Radioactive element contents have been determined for intrusive and effusive rocks of N. Kazakhstan. The possibility has been shown of using radioactivity as additional indicators in defining intrusive complexes of N. Kazakhstan and similar regions. The variations of the content of radioactive elements in igneous rocks are related to the different composition of intrusive and effusive bodies as well as the process of U migration and, to a lesser extent, to Th migration in the course of magmatic activity. The different migration ability of these elements is related to the presence of easily soluble, as well as to sparingly soluble U in the rocks. --Auth.

1-893. Grammakov, A. G., N. V. Kvashnevskaya, A. I. Nikonov, M. M. Sokolov, N. N. Sochevanov, S. A. Suppe, and G. P. Tafeyev. SOME THEORETICAL AND METHODICAL PROBLEMS OF RADIOMETRIC PROSPECTING AND SURVEY: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 732-43, graphs, diags., 3 tables, Geneva, United Nations, 1958, 18 refs.

Radiometric methods may be conditionally divided into 2 groups. In the first group are the so-called "prospecting methods," which are qualitative methods used in obtaining data for calculation of radioactive ore reserves. To the second group belong methods which have found wide application in prospecting radioactive ore deposits, primarily gamma and emanation methods. Radiometric anomalies cannot be interpreted without consideration of geological and geochemical factors. In this paper some theoretical problems of gamma logging and testing are discussed as well as problems relating to field radiometric methods and comprising, along with this theory, the main features of application of these methods in prospecting U ores. --Auth.

1-894. Berbezier, J., B. Blangy, J. Guitton, and C. Lallemant. METHODS OF CAR-BORNE AND AIR-BORNE PROSPECTING: THE TECHNIQUE OF RADIATION PROSPECTING BY ENERGY DISCRIMINATION: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 799-814, 13 figs. incl. illus., diags., graphs, 5 tables, Geneva, United Nations, 1958, 2 refs.

The idea of setting ray detectors of high efficiency on planes or on other vehicles was quite attractive. It was widely used as soon as the Commissariat à l' Energie Atomique undertook methodical surveys on vast Saharian and tropical countries of the Union Française.

Airborne prospecting involves 2 stages. The first systematic flights are organized according to a kilometric grid, and they make it possible to locate interesting occurrences. These occurrences are then studied with more detailed surveys, by plane or helicopter.

The working methods, as well as the outfit used to record radioactivity and height and position when flying, were improved while we developed methods for getting a better evaluation of results. We were then induced to study the composition of gamma radiation in altitude, the influence or rays emitted by some radioelements such as K and Th, the pollution of atmosphere, the noises resulting from topography, the adjustments due to altitude variation, and calibrating methods for our outfits.

Our 2 types of aerial scintillometers are described; one of them, sodium iodide crystals, the other, with organic plastic phosphors and transistors. We give here practical results which we got through systematic aerial-prospecting campaigns in the Hoggar; the numerous difficulties encountered are indicated. The awkward problem in U prospecting through aerial surveys is to identify immediately on board occurrences resulting either from U or from Th. For that purpose, our efforts were bent on the discrimination and selection of radiation energy. The radiation spectra of K, Th, and U have been studied in laboratories as well as in the field. Two aerial scintillation-counter units for discrimination and amplitude selecting have been set. The theore-

tical standard basis for this method and for field tests are defined. To conclude, we give the possibilities which are offered by this method, and we describe its use in foot and aerial prospecting.

In France, carborne prospecting is the only method we are now using, for cost reasons. The outfits are set, without any difference, on any form of transport. In order to determine the type of detector best suited to these radioactivity surveys, these detecting appliances have been completed and compared systematically during a few months campaign (a set of 50 Geiger-Müller meters, scintillation-counter equipment with sodium iodide, organic plastic phosphors).

The standard apparatus is a sodium iodide-crystal scintillation counter. Twin detectors sets are brought up on vehicles. Results are compared through graphic recording on a double-curve apparatus, for which development is synchronized with drive. --Auth. (transl.).

1-895. Moxham, R. M. GEOLOGIC EVALUATION OF AIRBORNE RADIOACTIVITY SURVEY DATA: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 815-19, 3 figs., Geneva, United Nations, 1958, 6 refs.

Development of large-volume crystal detectors for aerial radioactivity surveys and application of semiquantitative analytical techniques now permit geologic evaluation of regional surveys whereas previous qualitative surveying methods were generally limited to direct ore-finding techniques. The principal problems in geologic evaluation involve the precision and accuracy of measurement, graphic presentation of data, and interpretation.

The detector used by the U. S. Geological Survey [has been described earlier]. A discriminator permits selection of minimum pulse-height (energy) acceptance and is set as low as 50 kev. at the low-energy end of the spectrum to detect scattered low-energy photons. It is estimated that [at 500 ft.] 50% of the detectable gamma radiation from extended geologic units is in the low-energy part of the spectrum (50-200 kev). The important contribution of scattered photons necessitates minimum gating for detection of the very small variations in radioactivity that may result from significant variation in the geologic character of the source materials.

Results of a recent survey, made with DC-3 type aircraft along traverse lines spaced at 0.5 to 1 mi. and 500 ft. above the ground, indicate that the counting rate at a given place can be duplicated, on the average, within - 10%. Comparison of laboratory data with those computed from the survey records indicates that, for gross geologic features, contrasts in eU content of 20 ppm. are detectable with airborne equipment.

Geologic interpretation of radioactivity data depends strongly on topographic relief, geometric complexity of the outcrop pattern, and radioactivity contrast among geologic units. An excellent test area is the Coastal Plain of Texas. Here, low topographic relief, simple outcrop patterns, and large contrasting inter-unit radioactivity result in interpretable radioactivity trends.

The clean sands give rise to radiation "trenches", whose eU content is remarkably uniform over distances as much as 50 mi. The clays and siltstones by contrast are generally higher so that a typical radioactivity profile across the section shows a series of highs and lows reflecting the lithologic and mineralogic character of the Coastal Plain sedimentary sequence. The radioactivity patterns resulting from bedrock constituents are interrupted along the strike by local drainage-oriented trends caused by Recent alluvial deposits that mask the bedrock radioactivity. There may be additional modifications from soil-forming processes.

Areas in which U deposits occur on the Coastal Plain are characterized by gamma-ray anomalies as much as several hundred square miles in extent; the anomalous patterns cut across geologic boundaries, obliterating the "normal" sedimentary trends. Radiometric analyses show the anomalous intensity results from, on the average, only 10 to 20 ppm. excess eU with respect to "normal" values.

Superimposed on the most important of the large, areal anomalies are local high-amplitude peaks that occur over outcrops of ore. On the ground, visible U minerals are found in an area seldom exceeding several hundred square feet in extent, but there has been a dispersion of trace quantities of radioactive material such that abnormal radioactivity is detectable over many thousands of square feet adjacent to the ore.

The regional excess of radioactive materials and the local dispersion phenomenon greatly enlarge the targets for reconnaissance and detailed airborne surveys respectively and permit greater flight-line spacing and lower survey costs. Furthermore, the recognition of this pattern of regional and local anomalies superimposed on normal radioactivity levels greatly increases the usefulness of aerial surveys in identifying new districts that might profitably be prospected for U or Th. --Auth.

1-896. Boyle, T. L. LOW-LEVEL AERIAL RADIOMETRIC SURVEYING IN THE USA: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 820-24, 3 maps, graph, table, Geneva, United Nations, 1958, 8 refs.

Many organizations participated in the testing and development of airborne radiometric techniques. Increasingly sensitive radiation-detection instruments were devised and tested in light aircraft flying at low levels (20 to 100 ft.), in heavier aircraft at higher levels and in helicopters. Each method proved to have its special advantages and limitations. After considerable testing, the U. S. Atomic Energy Commission selected a light, tandem-seat, two-place aircraft, with pilot and geologic observer for crew, as being the most economical and practical approach to direct discovery of U deposits from the air. In addition to their application as "flying counters," the aircraft were also useful as tools for geologic studies and logistical problems.

Private industry quickly supplemented Commission airborne parties with their own aircraft, and an unprecedented search began. Vast areas in the western United States were surveyed quickly; 1140 anomalies were discovered by Government field crews and many additional anomalies by private industry. The significance of anomalies cannot be finally evaluated from the air. Anomalies discovered by Government aircraft were published monthly, and private air and ground parties quickly investigated them. The effectiveness of this cooperation between industry and Government is clearly demonstrated in the close correlation between ore reserves and the location of airborne radiometric anomalies in such important areas as Grants, New Mexico, the Tertiary basins of Wyoming, the Maybell-Lay district in NW. Colo-

rado, and the Edgemont district of South Dakota. It is interesting to note that outstanding results were obtained in the discovery of sedimentary-type deposits, but no significant vein-type deposits were found.

Although airborne radiometric surveying has been proven, without question, to be an effective and relatively cheap method of discovering exposed occurrences of U in the United States, its possible use in other countries must be carefully reviewed. In considering the advisability of undertaking an airborne radiometric-survey program, both geologic and management problems must be judged, e.g., 1) geologic characteristics of terrane and probability of making discoveries; 2) availability and advantages of other exploration techniques, accessibility of the area; 3) cost of the operation, finances available; 4) availability of materials, airports, and skilled personnel; 5) effect on and relationship to remainder of exploration organization. If, after considering all the problems, airborne radiometric surveying is undertaken, there is a good chance that a much better evaluation of the U potential of a region or country will be obtained. --Auth.

1-897. Loomis, Tom H. W., and Robert G. Blair. AIRBORNE RADIOMETRIC RECONNAISSANCE IN THE WIND RIVER BASIN, WYOMING, 1954: U. S. Atomic Energy Comm., [Pub.] RME-1072(rev.), 34 p., fig., map (in pocket), 3 tables, June 1957, pub. 1959, 3 refs.

A program of airborne radiometric reconnaissance for U was conducted in eastern Fremont and western Natrona counties, in central Wyoming, during the summer and fall of 1954, by the U. S. Atomic Energy Commission.

Rocks ranging in age from Precambrian to Quaternary were surveyed for radioactivity. The upper part of the Wind River formation of Eocene age was found to be the most favorable for U deposits. U minerals found at the anomalies included meta-autunite, autunite, phosphuranylite, uraniferous opal, torbernite, uraniferous carbonate-fluorapatite, uraniferous asphaltite, uranophane, dewindtite, and renardite.

Over 350 flying hours were logged by the Commission aircraft. A total of 204 anomalies was reported by the aircrew. Drilling on 2 of these anomalies discovered ore which is being mined. Surface features which may indicate other ore bodies warrant further investigations. --Auth.

1-898. Bowie, S. H. U., J. M. Miller, J. Pickup, and D. Williams. AIRBORNE RADIOMETRIC SURVEY OF CORNWALL: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 787-98, 13 figs. incl. illus., maps, diags., graphs, 2 tables, Geneva, United Nations, 1958, 12 refs.

The possibility of locating radioactive ores by gamma-ray measurements in aircraft was first studied in Great Britain in 1946, but at this time no instrument of the required sensitivity was available.

Since then, the development of Tl-activated sodium iodide scintillation counters and of transistor circuits and recorders has made it possible to design instruments which have the necessary sensitivity and are suitable for use even in light aircraft.

The survey method adopted was based on N.-S. flight lines flown parallel to the National Grid at intervals of 0.4 km. Each flight line commenced and finished over the sea where background level checks could be made. A constant ground clearance of 500 ft. was aimed at, though, because of local topography, limits of ± 100 ft. were allowed in the flight specification. Results obtained on single-crystal and 3-crystal scintillation counters are compared, and airborne anomalies are correlated with subsequent ground observations.

The use of airborne scintillation counters for primary reconnaissance surveys and as a tool in secondary prospecting is discussed and practical examples given. --Auth.

1-899. Bisir, D. P. DISCUSSION OF SOME RESULTS OF EXPERIMENTS IN RADIOACTIVE PROSPECTING FOR PETROLEUM AND NATURAL GAS IN ROMANIA: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 837-39, table, Geneva, United Nations, 1958, 13 refs.

The results of the work performed in 1956 and 1957 are presented, regarding: 1) the emanometric method of prospecting and the main results so achieved; 2) the radiometric prospecting method and the main results so achieved; 3) contributions on the physical principles of radiometric and emanometric anomalies, based on work performed in the laboratory and in the field. --Auth. (transl.).

1-900. Maldonado-Koerdell, M. RECIENTES ADELANTOS EN GEOFISICA Y GEOLOGIA SUBMARINAS EN LAS AREAS DEL OCEANO PACIFICO PROXIMAS A MEXICO [RECENT PROGRESS IN SUBMARINE GEOPHYSICS AND GEOLOGY IN PACIFIC OCEAN AREAS NEAR MEXICO]: Ciencia, v. 18, no. 7/8, p. 105-13, 3 figs., Nov. 1958, 25 refs.

Recent geophysical investigations of Pacific Ocean areas off Mexico include gravimetric surveys of the Clipperton submarine fracture zone; seismological observations on the size and shape of the "Meso-American" trench NW. of Acapulco; investigations of the structure and thickness of the crust in several western sections of Mexico using the pendulum and various types of gravimeters; and geodetic studies.

Among the most important recent contributions to the submarine geology of this area is data from Menard's work giving results of oceanographic expeditions by Scripps Institution of Oceanography and U. S. Navy Electronics Laboratory from the Aleutians to Hawaii and the Panama Canal (1948-1953). The possible cause of deformation and the extent of geologic processes influencing the character of the W. coast of North America were postulated. The relation between topography and sedimentation in the deep submarine depression S. of the Mendocino submarine fracture zone was also studied.

The Archipielago de las Revillagigedo was the subject of several oceanographic studies. The history and characteristics of the volcano Barcena and its relation to submarine geology, particularly to the Clarion submarine fracture zone, have been described and analyzed. The existence of a N.-S.-trending chain of submarine volcanos between Isla Socorro and Isla San Benedicto, whose southern continuation seems to be displaced by movements along the Clarion fracture zone, has been confirmed.

Other investigations included study of the volcano Barcena, the San Diego and Murray submarine frac-

ture zones, various aspects of sedimentology, the ecology of coastal lagoons of the western shore of Baja California, and the tectonics and geologic structure of the old landmass of Oaxaca. --G. E. Denegar.

7. GEOCHEMISTRY

See also: Stratigraphy 1-858; Geophysics 1-892; Mineralogy 1-935; Mineral Deposits 1-957, 1-958, 1-959, 1-961, 1-962, 1-964, 1-965, 1-970 through 1-981, 1-985, 1-986, 1-1034, 1-1038.

1-901. Hower, John. MATRIX CORRELATIONS IN THE X-RAY SPECTROGRAPHIC TRACE ELEMENT ANALYSIS OF ROCKS AND MINERALS: Am. Mineralogist, v. 44, no. 1/2, p. 19-32, 6 graphs, 6 tables, Jan./Feb. 1959, 11 refs.

Three matrix effects must be accounted for in x-ray spectrographic analysis. They are: (1) attenuation of the incoming beam, (2) mutual excitation of the elements, and (3) absorption of the outgoing fluorescent radiation. Only effects (1) and (3) are appreciable for most trace elements in the x-ray spectrographic analysis of common rocks and minerals. The effects are determined by the mass absorption coefficient of the rock or mineral. Curves are plotted of the mass absorption coefficient versus wave length for elements that are commonly major constituents in rocks and minerals. These plots show that the relative absorptions of the elements are virtually constant at all wave lengths. Curves are presented of the absorption of various rocks relative to an aluminum oxide standard. The relative absorptions are virtually constant between absorption edges. A complete matrix correction can be made for Ni and heavier elements by determining the absorption of a rock relative to aluminum oxide at one wave length. The relative absorption can be determined by 2 methods: (1) by calculation if the major constituent analysis is known; the necessary data are presented, (2) by use of an internal standard if it is not. Partial matrix corrections can be made for the lighter elements Co, Mn, Cr, V, and Sc. Both methods are illustrated. --Auth.

1-902. Dachille, Frank, and Rustum Roy. A NEW HIGH-PRESSURE FORM OF B_2O_3 AND INFERENCES ON CATION COORDINATION FROM INFRARED SPECTROSCOPY: Am. Ceramic Soc., Jour., v. 42, no. 2, p. 78-80, 2 figs., table, Feb. 1959, 12 refs.; also pub. as: Pennsylvania State Univ., College of Mineral Industries, Contr. no. 57-66.

A new crystalline variety of B_2O_3 has been prepared at pressures above 22,000 atmospheres and above 400°C. The properties are listed. These moderate pressures also are sufficient to catalyze the crystallization of the more common hexagonal form from B_2O_3 glass. Pressures, however, of up to 50,000 atmospheres will not convert GeO_2 quartz to GeO_2 rutile at room temperature. From the infrared absorption patterns of appropriate phases it can be shown that in coesite the tetrahedral coordination of Si^{4+} (or Be^{2+} in the model BeF_2-coesite phase) must be unchanged. In the new form of B_2O_3, however, the coordination number must be substantially different from that in the common hexagonal B_2O_3. --Auth.

1-903. Harris, L. A. PRELIMINARY STUDY OF THE PHASE EQUILIBRIA DIAGRAM OF ThO_2-SiO_2: Am. Ceramic Soc., Jour., v. 42, no. 2, p. 74-77, 5 figs., table, Feb. 1959, 3 refs.

A preliminary study of the system ThO_2-SiO_2 supported the premise that the system CaF_2-BeF_2 is a model for this silicate system. The only compound present was the monoclinic form of $ThSiO_4$ (huttonite), which melted incongruently to ThO_2 and liquid at 1975° ± 50°C. as determined from a series of powder x-ray spectrometer patterns. The eutectic temperature as tentatively determined is 1700° ± 10°C. at a composition of greater than 95% by weight of SiO_2. No solid-solution areas were observed. The quenching samples were fired in a modified oxygen-acetylene furnace which was developed to insure accurate temperature readings and to retain the effects of heating the samples in air. --Auth.

1-904. Sastry, B. S. R., and F. A. Hummel. STUDIES IN LITHIUM OXIDE SYSTEMS: III, LIQUID IMMISCIBILITY IN THE SYSTEM Li_2O-B_2O_3-SiO_2: Am. Ceramic Soc., Jour., v. 42, no. 2, p. 81-88, 10 figs. incl. illus., graph, 3 tables, Feb. 1959, 20 refs.; also pub. as: Pennsylvania State Univ., College of Mineral Industries, Contr. no. 57-67.

Glasses within the ternary system Li_2O-B_2O_3-SiO_2 containing less than 25.6% Li_2O can be broadly classified into 3 groups according to their behavior during cooling or heating. One group, containing either more than 18% Li_2O or less than 20% SiO_2, yields clear glasses during slow or rapid cooling. The second group, containing approximately 5 to 15% Li_2O and 26 to 90% SiO_2, yields dense white opal glass during slow or rapid cooling. The third group, located at the outer edge of the second group, cools to room temperature as clear glasses but develops opacity when reheated to temperatures between 550° and 880°C. It has been shown by electron microscopy that the opacity is due to liquid immiscibility, the matrix glass containing well-formed spheres of the dispersed phase. Some of the clear glasses of both groups have been shown to consist of 2 immiscible phases. The size of the dispersed units in the spontaneous opal glasses and also the reheated opal glasses can be controlled by the variation of the reheat treatments. The phase separation reported here is beyond the resolution of the petrographic microscope and can be detected only with the high resolution of the electron microscope. Accessory evidence is given to show that the phases are noncrystalline. --Auth.

1-905. Smales, A. A., D. Mapper, J. W. Morgan, R. K. Webster, and A. J. Wood. SOME GEOCHEMICAL DETERMINATIONS USING RADIOACTIVE AND STABLE ISOTOPES: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 242-48, 7 tables, Geneva, United Nations, 1958. 27 refs.

The ready availability of a nuclear reactor and of separated stable isotopes at Harwell has encouraged the application to geochemical problems of the 2 highly sensitive and specific analytical methods of

neutron activation and mass-spectrometer isotope dilution. The problems described in this paper cover the determination of elemental abundances in meteorites, and of geological age of minerals by the Rb/Sr method.

Elemental abundances

(a) The determination of Cu, Cr, Ge, As, and Sb in iron meteorites by neutron activation. Accurate and quite sufficiently precise methods have been developed for these trace elements using a composite radiochemical separation scheme on irradiated single samples of about 200 mg. Figures have been obtained initially for a group of 15 iron meteorites, 2 stony irons, and the troilite phase of Canyon Diablo meteorite.

For the irons, the Cu content varied from 7.8 to 434 ppm.; Cr from 5.9 to 185 ppm.; Ge from 0.2 to 359 ppm.; As from 0.6 to 30 ppm.; and Sb from 0.01 to 0.78 ppm.

The divisions of iron meteorites into "quantized groups" according to Ge (and Ga) contents, first recognized by Harrison Brown and his co-workers, is confirmed in the work reported here, and although a much smaller number of samples was available, there is some evidence pointing to an enlargement of the number of groups postulated by Brown.

Ge figures in this work are generally about 30% higher than those quoted by Brown for the same meteorites.

(b) The determination of Cs in stony meteorites by mass-spectrometric isotope dilution. Cs determinations have been made recently both by neutron-activation analysis and by isotope-dilution analysis. The former method was applied to a set of 8 stony meteorites (Cabell and Smales) and yielded values in the range of 0.01 to 0.1 ppm., whereas Gordon, Friedman, and Edwards, using the second method, obtained results of 0.3, 0.5, and 0.9 ppm. for 3 meteorites, supporting the value of 0.4 ppm. proposed by Suess and Urey for the cosmic abundance of Cs.

The analyses described in this paper were made by the mass-spectrometric isotope-dilution method; fission Cs was used as the tracer. Determinations have been made for 7 stony meteorites of which 2 were investigated earlier by Cabell and Smales, and these results clarify the question of the Cs abundance. For the 2 common samples, the values found confirm the neutron-activation analyses, and, for the total of 13 stony meteorites examined, the Cs contents are distributed over the range of 0.01 to 0.03 ppm. with a mean value of about 0.1 ppm.

Rb/Sr age determination

Rb/Sr ages have been found by stable-isotope-dilution analysis for several feldspars from regions of known geological age, and with one exception there is close agreement between the 2 ages. For a microcline perthite from Brevig, Norway, the Rb/Sr age found is Precambrian, whereas the apparent geological age is Permian. --Auth.

1-906. Vinogradov, A. P. METEORITES AND THE EARTH'S CRUST (GEOCHEMISTRY OF ISOTOPES): In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 255-69, 4 photomicrographs, 4 graphs, 23 tables, Geneva, United Nations, 1958.

The formation of zones of definite thickness with a high concentration gradient of fusible and volatile compounds, like the earth's crust, depends not only on the composition of the initial material, but on mantle thickness as well, i.e., on the size of the planets and other bodies. In this case, as a result of melting and outgassing [due to radioactive heat of U, Th, and K], dunite (olivine) is the residual rock. A comparison of the distribution of a number of elements and isotope ratios, as well as the zonal melting of meteorites and silicates, points to a different character of separation processes giving different meteorite types as compared with differentiation processes taking place in the earth's crust: fractional crystallization, hydrothermal activity, etc. Meteorite separation processes develop in reducing conditions.

In meteorite formation, 2 main processes can be distinguished: mixing agglomeration of silicate chondrules and Fe and troilite masses, when chondrites, Fe and stony meteorites are formed; and the formation of achondrites from chondrites on small-size bodies, consequently in the absence of a sufficient amount of volatile compounds. --From auth. concl.

1-907. Larsen, Esper S., Jr., David Gottfried, and Marjorie Molloy. DISTRIBUTION OF URANIUM IN THE VOLCANIC ROCKS OF THE SAN JUAN MOUNTAINS, SOUTHWESTERN COLORADO: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 509-14, graph, 15 tables, Geneva, United Nations, 1958, 4 refs.

The volcanic rocks of the San Juan region underlie an area of approximately 6,500 sq. mi. Except for Precambrian rocks and a small amount of volcanic conglomerates in the Animas and McDermott formations, they are Miocene and younger in age. The mass is composed of tuff, welded tuff, breccia, lava flows, and some intrusive rocks. The fragments are volcanic except near the borders of the mass where conglomerates of Precambrian age and other rocks appear.

There are about 6 major groups of volcanic rocks, separated by extensive erosion intervals, and each of the main groups is divided into several subgroups, separated by a sharp break in lithology or by an interval of erosion. The rocks range from basalts and trachydolerites to rhyolites. The predominant rock type is dark quartz latite; light-colored quartz latites and rhyolites are nearly as abundant. U analyses have been made on 115 samples of these rocks. The trachydolerites carry approximately 1.3 ppm. U which is about the average, or a little higher than the average for such rocks. The U content of the dark quartz latites ranges from 2.2 to 3.0 ppm. which is high for such rocks. The light quartz latites have a U content of about 3.6 ppm. and the rhyolites 5.8 ppm. U. This amount is close to the average content for such rocks, and is comparable to that in the more siliceous intrusive rocks of the southern California batholith. The weighted average of rock in the area is 2.9 ppm. U, a little higher than in granitic rocks in the Sierra Nevada batholith.

Study of the distribution of U in the different minerals of a rhyolite containing 6.6 ppm. U showed that more than 90% of the U is in the groundmass. Although the accessory minerals, zircon and sphene, are relatively high in U content (800 to 71 ppm., respectively), they are present in amounts too small to contribute significantly to the total U content of the rock. --Auth.

1-908. Roubault, Marcel, and René Coppens. MIGRATION OF URANIUM IN CRYSTALLINE ROCKS AND THE POSSIBLE RELATION OF THIS PHENOMENON TO THE GENESIS OF CERTAIN DEPOSITS: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 335-37, 3 figs., table, Geneva, United Nations, 1958, 15 refs.

The presence of autunite in granite is a phenomenon much more common than one would expect.

The discovery of autunite, of recent formation, in the granites of the Mallièvre region in Vendée has directed the researchers of the Centre de Recherches Radiogéologiques de Nancy toward this problem and has resulted in more new observations of the same type.

The studies undertaken in this region showed that granites with autunite contain a high proportion of unmineralized U. The U content in these granites is generally higher than normal, without, however, exceeding 20 ppm. The rocks not containing autunite were found to have U contents of the same order which enables us to consider a previous U enrichment followed by, in certain cases, subsequent mineralization.

On the other hand, it is possible to prove that if the U content does not exceed 10 ppm., there is a close correlation between U and K contents (coefficient of correlation: 0.7 for 60 samples). As a correlation between primary U and K content in granites is generally admitted, it is possible to consider that secondary U would not have come from granite, but, in fact, is an alteration product of primary U.

The rocks studied are more or less altered. Unaltered biotites contain radioactive inclusions but are not themselves radioactive. Certain biotites were crushed, altered, and transformed into chlorites. These do not generally contain radioactive inclusions but contain diffused radioactivity distributed throughout their mass and chiefly concentrated in ferruginous areas. Sometimes uniform radioactive inclusions not destroyed but comprising a zone of oxidation on the borders are noted. Some radioactive inclusions half destroyed and partially replaced by nonradioactive yellow-brown oxides and brownish spots, but enclosed by a pleochroic halo, are noted. Some fissures contain more or less radioactive iron oxides.

It seems that U removal would be correlated to biotite alteration which implies, at least partially, that water action serves as a vehicle for hexavalent U.

The removal process could be outlined in the following manner: 1) oxidation and destruction of certain radioactive inclusions, freeing U; 2) oxidation of biotite and other ferruginous minerals, freeing Fe^{++}; 3) precipitation of U^{6+} in U^{4+} by Fe^{++} and adsorption of U by iron oxides; 4) U would stay provisionally in the altered minerals or would escape with oxides through the fissures; 5) P would be available from the destruction of phosphates (apatite, xenotime, monazite) and would fix, to some extent, U in autunite; 6) when the U content of granite exceeds 10 ppm., the extra possibly would be the result of transportation made possible by the proposed process.

The presence of autunite in granite does not necessarily imply the existence of a U deposit nearby; the mineral may possibly have been formed directly from the altered granitic massifs. But, inversely, a U deposit, vein type in particular, is not necessarily the consequence of long-distance hydrothermal transportation from a deep-seated origin; it may only be the result of concentration in situ or the result of weak transportation of U normally diffused throughout the granitic massifs and lost in transport, e.g., following the above-mentioned outline.

The observations made confirm notes in the same way presented before by the authors. --Auth. (transl.).

1-909. Borisenko, L. F., and N. V. Lizunov. THE PROBLEM OF THE RELATIVE ABUNDANCE OF SCANDIUM IN WOLFRAMITES: Geochemistry [Geokhimiya], 1958, no. 3, p. 279-86, 3 illus., 6 tables, 11 refs.

The distribution of Sc in wolframites of various rare-metal deposits has been studied. On the basis of 450 quantitative spectral analyses of wolframites from 47 deposits, it has been established that: 1) as a rule, higher Sc concentrations (0.02-0.2% Sc_2O_3) are found in wolframites from high-temperature pneumatolyto-hydrothermal greisen-type deposits; 2) the mean Sc content in wolframites from pneumatolyto-hydrothermal deposits (0.04% Sc_2O_3) is at least an order higher than in wolframites from lower-temperature hydrothermal deposits (0.002% Sc_2O_3). In a large number of wolframite specimens from low-temperature quartz veins (often with sulfides) Sc has not been detected.

It has been found that Sc usually concentrates in wolframites and ferberites (up to 0.2% Sc_2O_3), whereas huebnerites have lower Sc contents (up to 0.02% Sc_2O_3). --Auth.

1-910. Vainshtein, E. E., G. A. Sidorenko, A. I. Tugarinov, and N. V. Turanskaya. PROPORTIONS OF RARE EARTHS IN GADOLINITES: Geochemistry [Geokhimiya], 1958, no. 3, p. 310-13, 2 tables, 4 refs.

X-ray structural and x-ray spectral studies of 5 samples of gadolinite from pegmatites of Sweden, Norway, and the Caucasus have been carried out. The results show that the ratio of Ce earths is relatively constant whereas the ratios of Y earths show slight variations. These variations do not influence the structure of the minerals. The existence of cerogadolinite is hardly possible. --Auth.

1-911. Krylov, A. Ya. RADIOACTIVITY OF VARIOUS ROCK COMPLEXES OF THE TERSKEI ALA-TAU MOUNTAINS: Geochemistry [Geokhimiya], 1958, no. 3, p. 240-47, 4 tables, 9 refs.

The influence of Caledonian granite intrusions on the variations of the radioactivity of the earth-crust area in Tyan-Shan [Tien Shan, U.S.S.R., 42°N. 80°E.] has been considered. Several thousands of rock specimens of various complexes have been analyzed for U, Th, and K. The total chemical compositions of rocks of various complexes are given.

The principal conclusions are the following: during the formation of granitic batholiths (in the case of replacement of host rocks) radioactive elements (U, Th, K) are carried in to an essential extent together with Si and alkalis. At the same time, Ca and Mg are carried out in considerable quantities, and to a lesser degree, Fe, Mn, and Ti. This tendency grows in the second phase granites, which represent the further development of the magmatic process. --Auth.

1-912. Nesterenko, G. V., Z. V. Studenikova, and Ye. N. Savinova. RARE AND DISPERSED ELEMENTS IN SKARNS OF TYRNY-AUZ [SOVIET ARMENIA]: Geochemistry [Geokhimiya], 1958, no. 3, p. 287-96, 10 tables, 13 refs.

Distribution and behavior of the major and 12 minor elements in skarns of Tyrny-Auz, Soviet Armenia, are investigated from the standpoint of changes in bulk rock and specific mineral composition. The minor elements studied are Sn, Ge, Ga, Co, Ni, Cr, V, Ti, Zr, Sr, Ba, and Be. The skarn zone occurs in an anticline along a biotite hornfels-marble contact; the hornfels is 80% skarnized, the marble 20%. In sequence of increasing alteration, skarn zones in the biotite hornfels are amphibole-biotite hornfels, pyroxene hornfels, and garnet pyroxenites; skarn zones in the marble are vesuvianite-wollastonites and garnet or non-garnet pyroxenites. Skarnization of the hornfels produced marked increase in Fe, Mn, and Ca; decrease in Al and Ti; and almost complete removal of alkalies. Skarnization of the marble resulted in increase in Si, Ti, Al, Fe, Mg, and Mn. Only Fe and lesser amounts of Mn are believed to have been carried in by solution; gains and losses of other major elements are caused by redistribution of the elements among and within the original rocks present. Of the minor elements, only Sn and smaller amounts of Ge are believed to have been brought in by solution. Ga, Co, Ni, Cr, V, Ti, Zr, Sr, Ba, and Be were abstracted from the biotite hornfels and redistributed during skarnization. Cr, V, Ti, Zr, Sr, and Ba were withdrawn from the hornfels faster than Ni, Ga, Co, and Be are derived from the hornfels at a barely perceptible rate. Chemical analyses are given for major and the 12 minor elements in biotite hornfels, marble, and their respective skarns. The abundance of Cr, V, Ti, Sr, and Ba in the skarn minerals biotite, plagioclase, pyroxene, garnet, wollastonite, and vesuvianite and Ge, Sn, Co, and Ni in these minerals as well as in pyrrhotite, pyrite, chalcopyrite, and sphalerite indicates to what degree these elements isomorphously enter the crystal structure of silicates and sulfides. --Auth.

With editorial comment, p. 296.

1-913. Vainshtein, E. E., A. I. Tugarinov, A. M. Tuzova, and I. D. Shevaleevskii. HAFNIUM-ZIRCONIUM RATIOS IN METAMORPHIC AND METASOMATIC ROCKS: Geochemistry [Geokhimiya], 1958, no. 3, p. 305-309, 2 tables, 2 refs.

The distribution of Zr and Hf in 14 rock samples from the Upper Suite of the Krivoi Rog series [in the U.S.S.R.] has been studied. It has been shown that the zirconium oxide content in unaltered metamorphic rocks varies from 3×10^{-3} to 24×10^{-3}% wt.; the ZrO_2/HfO_2 ratio varies from 20 to 40. In metasomatic rocks (especially in Na metasomes), an appreciable enrichment in Zr is observed (up to 170×10^{-3}% wt.). The ZrO_2/HfO_2 ratio for the same rocks increases sharply up to 112 which is in agreement with the data on zircons obtained by the authors earlier. This phenomenon can be explained by the differences in the migration capability of Zr and Hf during Na metasomatism as hypothetical carbonate complexes and by the different values of their ionic radii and ionization potentials. --Auth.

1-914. Pierce, A. P., J. W. Mytton, and P. R. Barnett. GEOCHEMISTRY OF URANIUM IN ORGANIC SUBSTANCES IN PETROLIFEROUS ROCKS: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 192-98, 2 figs., table, Geneva, United Nations, 1958, 15 refs.

Detailed geochemical studies have been made of U-bearing organic mineraloids from several dozen localities in the United States and other countries.

The materials studied occur as epigenetic impregnations and nodules in sedimentary host rocks, which range in age from Precambrian through Tertiary and represent chiefly marine and fluvial environments of deposition.

U is present in these materials largely as uraninite although coffinite is present also in some localities. Th, where present, occurs in thorite. U, Pb, and Pb-isotope analyses indicate that the Pb content is largely of radiogenic origin.

X-ray studies of these substances commonly show the presence of poorly oriented graphitic C and other diffuse diffraction bands that are interpreted as due to the presence of napthenic and aromatic structures. Additional studies indicate that the amount of graphitic C, the C/H ratio, and the refractive index of these substances increase systematically with the total radiation flux which they have undergone. The large changes that occur in these parameters provide new criteria for determining the absolute age of these types of materials by radioactivity methods.

Comparison of the x-ray data, refractive indices, and organic analyses of the uraniferous organic mineraloids with similar data on other naturally occurring organic substances suggests that the uraniferous mineraloids are derived from surface-active and water-soluble organic substances present in petroleum and petroleum waters. --Auth.

1-915. Rozhkova, E. V., E. G. Rasumnaya, M. B. Serebryakova, and O. V. Shcherbak. THE ROLE OF SORPTION IN THE PROCESS OF URANIUM CONCENTRATION IN SEDIMENTARY ROCKS: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 420-31, 6 graphs, 10 tables, Geneva, United Nations, 1958, 21 refs.

The study of a number of U-bearing sedimentary rocks was the first stage of investigation. It was found that U is connected only with certain components of these rocks which proved to contain no U minerals. Assumptions were made as to the possibility of accumulation of U in these components as a result of sorption processes.

At the second stage of investigation experiments were carried out with the sorption of U from the solutions of its salts. Experiments were made with the rock components mentioned above under conditions which made it possible to determine the sorption capacity of these components and to establish the basic regularities of the sorption process.

The comparison of the results of the first and second stages of the investigation presumes the possibility of U being accumulated in sedimentary rocks by sorption at various periods of their formation as well as in the process of epigenetic ore formation in sedimentary deposits. --Auth. (transl.).

1-916. Szalay, A. THE SIGNIFICANCE OF HUMUS IN THE GEOCHEMICAL ENRICHMENT OF URANIUM: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958.

Proceedings, v. 2, Survey of Raw Material Resources, p. 182-86, 6 figs., Geneva, United Nations, 1958, 9 refs.

In 1949, U was found in various coal strata of the Transdanubian part of Hungary by the author and collaborators.

The author became interested in the cause of the enrichment of U in coal. Systematic investigations clarified this phenomenon, and convincing experiments demonstrate that humic acids are responsible for the enrichment of U. A general outline of these experiments is given including the latest results.

The first experiments of the author (in 1951) showed that lignite, peat, and other similar decayed plant substances adsorb U very quickly from an aqueous solution in the pH range of $3 < pH < 7$. The adsorption on a given peat preparation shows an adsorption isotherm, which can be treated according to the formalism of Langmuir. The adsorption property of a peat preparation can be expressed quantitatively by 2 numerical constants, a "saturation capacity" and an "enrichment factor." The saturation capacity is about 1 milliaequivalent UO_2^{++}/g. of peat, and the enrichment factor is about 1:10,000 at about pH $\sim$5.

Peat contains a large proportion of humic acids. Experiments showed that these components are responsible for the adsorption, and the phenomenon itself is a cation exchange process, in which the H^+ ions of the humic acids are exchanged for UO_2^{++} ions. Tracer experiments showed that Th^{4+} ions are reversibly adsorbed in laboratory experiment, i.e., they are steadily dynamically exchanged with Th^{4+}ions in the aqueous phase.

A comparison of the enrichment factor of 1:10,000 with the usual concentration of U in natural waters and bioliths demonstrates good agreement. When peat is in contact with water, at a pH between 5 and 7, a U concentration of 10 mg./ton water is sufficient to cause an enrichment of 1:10,000, i.e., 100 g. U/ton peat.

It seems that humic acids are the most important agents in nature responsible for the enrichment of U in peat. Though some other special chemical environments may be responsible for a chemical precipitation in some areas of limited extension and for the origin of further secondary concentration of U, the general importance of humus in the geochemical enrichment of U in nature cannot be doubted. --Auth.

1-917. Vine, J. D., V. E. Swanson, and K. G. Bell. THE ROLE OF HUMIC ACIDS IN THE GEOCHEMISTRY OF URANIUM: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 187-91, 2 figs., table, Geneva, United Nations, 1958, 14 refs.

Carbonaceous matter is probably the most characteristic component of sedimentary rocks containing abnormal concentrations of U, but much evidence suggests that only certain types of carbonaceous matter have the capacity to assimilate, fix, or transport U. The indigenous carbonaceous matter in sedimentary rocks is considered here as a complex, gradational series of organic remains with 3 distinct end-members - decayed wood, hydrocarbons, and C. Two major categories of carbonaceous matter may be recognized, sapropelic and humic. Sapropelic matter is rich in H and yields bitumens. Humic matter is rich in O and yields humic-acid extracts to alkaline solutions. C is the metamorphic end-product of both humic and sapropelic matter. Solid humic matter and the extracted humic acids are the important carbonaceous materials in the geochemical cycle of U. Experimental results show that humic substances are capable of assimilating 5% or more U by dry weight from uranyl solutions forming uranyl humate.

Solid humic matter is the principal constituent of peat, lignite, and of the dispersed carbonaceous matter in non-marine sedimentary rocks. Natural alkaline solutions such as sodium carbonate ground water readily extract humic acids from the solid humic matter to form a colloidal solution; upon acidification, or addition of some salts (e.g., those of Ca), the dispersed humic acids flocculate to form a reddish-brown gel. Humic acids and humates readily remove U from solution by adsorption, ion exchange, or chemical complexing. Once assimilated, the U remains fixed under most natural conditions of transportation and deposition.

Some carbonaceous U ore deposits of the type commonly but erroneously called "uraniferous asphaltite" are thought to represent deposits of uranyl humates that have been carbonized and indurated by alpha-particle irradiation. Evidence is presented to show that a small humic-matter component of the carbonaceous material in marine black shales may be responsible for retaining most of the U disseminated in these rocks. --Auth.

1-918. Germanov, A. I., S. G. Batulin, G. A. Volkov, A. K. Lisitsin, and V. S. Serebrennikov. SOME REGULARITIES OF URANIUM DISTRIBUTION IN UNDERGROUND WATERS: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 161-77, 18 figs., 4 tables. Geneva, United Nations, 1958, 20 refs.

The paper partially shows the results attained by the authors during many years of work investigating the behavior of U and other elements in underground waters in some U-bearing regions. The desire to approach the solution of the problem from geochemical positions required a close coordination between hydrogeological and hydrochemical data (dynamics, chemical and gas composition of waters, etc.) on the one hand and the data on mineralogy, geomorphology, tectonics, climate, etc., on the other.

The authors show the influence of a number of agents on U distribution in underground waters: oxidizing-reducing conditions, climate, etc. The question of the effect of underground waters on U deposits is dealt with but briefly. A supposition is made on the possible role they play in the formation of deposits. --Auth. summ.

1-919. Scott, R. C., and F. B. Barker. RADIUM AND URANIUM IN GROUND WATER OF THE UNITED STATES: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 153-57, map, table, Geneva, United Nations, 1958, 10 refs.

The normal background concentrations of Ra and U in water from some of the principal water-bearing formations have been evaluated for 486 samples collected from places throughout the United States. The evaluation was expressed in 2 ways: the actual concentrations found in the samples, and a concentration ratio - the ratio of U (in parts per billion) and Ra (in micromicrocuries per liter) to the dissolved-solids

concentration in each sample. The medians and ranges of the concentrations and concentration ratios are shown for each geotectonic region of the United States. The United States has been divided into 10 major geotectonic regions: Gulf Coastal Plain, Atlantic Coastal Plain, Appalachian Paleozoic orogenic belt, Canadian shield, Ozark-Ouachita system, Eastern Central stable region, Western Central stable region, Rocky Mountain Cretaceous-Cenozoic orogenic belt, Colorado Plateau, and Pacific Paleozoic-Mesozoic-Cenozoic orogenic belt. The smallest median U concentrations were found in the Gulf and Atlantic Coastal Plains and the Ozark-Ouachita system. The smallest median U concentration ratios were in the Gulf and Atlantic Coastal Plains and Eastern Central stable region. The greatest median U concentration and concentration ratios were found in the Western Central stable region and the Canadian shield, respectively. The smallest median Ra concentrations and concentration ratios were in the Pacific Paleozoic-Mesozoic-Cenozoic orogenic belt, and the largest medians were found in the Ozark-Ouachita system.

The concentrations of Ra and U occurring naturally in ground water are determined by (1) the physical and chemical characteristics of the water and (2) the availability of the elements in the rocks through which the water has passed. Inferences concerning the geochemical cycles of these elements are drawn from their concentrations, the chemical characteristics of the water, and the geology of each geotectonic region. A threshold of significant concentration is suggested for hydrogeochemical prospecting in each geotectonic region. --Auth.

1-920. Vinogradov, A. P., E. I. Dontsova, and M. S. Chupakhin. THE ISOTOPIC COMPOSITION OF OXYGEN IN IGNEOUS ROCKS AND METEORITES: Geochemistry [Geokhimiya], 1958, no. 3, p. 235-39, table, 8 refs.

The O^{16}/O^{18} ratio has been determined in stony and iron-stony meteorites, in ultrabasic, basic, and acid rocks. The data obtained show that the O^{16}/O^{18} ratio exhibits a tendency to an increased O^{18} content towards acid rocks. The O^{16}/O^{18} ratio values in ultrabasic rocks and meteorites are very similar. Some geochemical conclusions have been made on this basis. --Auth.

1-921. de Vries, A. E., and A. Haring. AN IMPROVEMENT ON AGE DETERMINATION BY THE C^{14} METHOD: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 249-50, table, Geneva, United Nations, 1958, 3 refs.

The age determination of samples containing C^{14} has been improved by increasing the specific activity in a known way in a thermal diffusion column.

The sample is converted to CO prior to enrichment, and a suitable quantity of gas is withdrawn from the bottom of the column when the C^{14} and the O^{18} concentration have been increased sufficiently. From the O^{18} abundance the enrichment of the C^{14}, which is not the same, is obtained.

Samples have been enriched by a factor of 12 in the C^{14} concentration which means a gain of about 20,000 years in the age determination. --Auth.

1-922. Fuson, Robert H. RADIOCARBON DATING: Professional Geographer, v. 11, no. 2, p. 5-7, March 1959.

Radiocarbon (C^{14}) methods of age determination began at the University of Chicago in 1931; the first age measurements were published in 1951. Since then, many articles dealing with methods of radiocarbon age determination have been published.

Radiocarbon dating stems from the fact that the rate of conversion of the unstable C^{14} isotope to N^{14}, or atomic disintegration, is known and measurable; C^{14} has a half-life of 5568±30 years. The source of C^{14} is the upper atmosphere, where these carbon atoms unite with oxygen to form carbon dioxide. Radiocarbon is circulated in carbon dioxide through every living plant and animal. Atomic decay begins on the death of the organism.

Although C^{14} dating should become a primary technique for geographic research, other methods of age determination should be utilized. --G. E. Denegar.

1-923. Sinex, F. Marott, and Barbara Faris. ISOLATION OF GELATIN FROM ANCIENT BONES: Science, v. 129, no. 3354, p. 969, Apr. 10, 1959, 9 refs.

The isolation and characterization of gelatin from 12,000-year-old deer antlers is described. Use of gelatin from ancient bones for C^{14} dating may improve the accuracy of the dating procedure because gelatin is not likely to be contaminated by extraneous C. --Auth.

1-924. Merrill, J. R., M. Honda, and J. R. Arnold. BERYLLIUM GEOCHEMISTRY AND BERYLLIUM-10 AGE DETERMINATION: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 251-54, 3 tables, Geneva, United Nations, 1958, 13 refs.

The nuclide Be^{10}, whose presence in nature was demonstrated last year by Arnold and by Peters and co-workers, has a half-life of $2.5 \cdot 16^6$ years. It is produced by the action of cosmic rays on the atmosphere. Because the half-life is unique among natural species, and because it falls in a very interesting time span, there appears to be considerable interest in developing a method of age determination based on its use. Such research has many auxiliary points of interest, among them the hope of learning about possible variations in intensity of cosmic radiation on this time scale.

Measurements of Be^{10} have thus far been confined to deep-sea sediments because of their relatively high specific activity.

Before measurements of age can be made with confidence, the sedimentary cycle of Be^{10} and normal Be must be understood. The early history of Be^{10} is rather well known, since it must behave in about the same way as Be^7 formed under the same conditions. Kharkar has shown that Be^7 in rain water is present in true solution. We can assume that the Be^{10} introduced into the sea comes overwhelmingly directly from rain, since the bulk of rain falls into the sea, and the Be^{10} in rain over land will be effectively removed by the soil. Thus the source of Be^{10} in the ocean is diffuse, though presumably not uniform on a world scale.

Very few reliable measurements exist of Be in rocks and sediments, the bulk of them obtained by Sandell's morin method. We have developed an analytic method for Be based on a method of Adam,

Booth, and Strickland, and using isotope dilution with Be^7 to determine chemical yield. The method has an apparent accuracy of 0.2 micrograms for a single determination. A few dozen analyses of sediments and of standard igneous rocks have been completed. The red-clay cores so far studied show concentrations of Be in the narrow range of 2-3 ppm.

In collaboration with G. Arrhenius we have measured a number of mineral components and size fractions in the cores. The finer fractions show somewhat higher concentrations. Among authigenic minerals the composition of phillipsite fractions is highly variable and perhaps depends on impurities. The concentration in Fe-Mn aquate minerals is in the region of 5 ppm.

Our most serious effort has been devoted to determination of dissolved Be in deep ocean water. Given an average rate of deposition of red clay of 1 mm./1000 years, and a Be content of 3 ppm., we can calculate the annual rate of removal of Be from the sea. If we know its concentration, and hence the total inventory in sea water, we can compute its average residence time. If this is long compared to the gross mixing time of the oceans (perhaps a few centuries), the concentration of both Be^{10} and Be^9 in the ocean, and their ratio, should be uniform in space and time. Thus their ratio in an authigenic mineral would be dependent only on its age, and the simple equation used for C^{14} dating would apply directly. Conversely, if the residence time is short, both isotopes will show major and independent concentration variations in the sea.

We have been able to measure this concentration in a series of deep and surface sea-water samples, and find it to be of the order of 10^{-13} parts per part. The technique used is briefly as follows. The samples were obtained using 6-liter plastic Van Dorn samples, which had been previously shown to adsorb very little Be^7 tracer from sea water. The samples were placed in 50-liter polyethylene bottles, and carrier-free Be^7 added. Each sample was passed through a small column of cation exchange resin, which had been prepared in the Fe (III) form and then treated with dilute aqueous NH_3 to produce a molecularly dispersed ferric hydroxide coating. These columns were stable, unaffected by the major ions of sea water, and capable of removing Be at high flow rates (typically 300 volumes/volume hour). A Millipore filter before the column removed particles. The column was eluted with HCl, and the sample treated as in our mineral analysis. No Be was seen in any sample, indicating a concentration below 2.10^{-12}. A. Leoni and N. Nachtrieb kindly analyzed our final samples by an emission-spectrographic method, and showed that the original concentrations were of the order of $1-2.10^{-13}$, well below the concentration of Au in sea water. A number of auxiliary experiments were necessary to validate this result.

The column separation method may be applicable to other trace-element studies.

The average residence time for Be, computed from these data, is about 100 - 200 years. This is only a little longer than those for Fe and Al, and suggests a co-precipitation mechanism for Be removal. Thus, the simple model does not apply well, and one must depend for age measurements on a more thorough knowledge of local and general conditions. Models which may prove useful are described. --Auth.

1-925. Rosholt, John N., Jr. RADIOACTIVE DISEQUILIBRIUM STUDIES AS AN AID IN UNDERSTANDING THE NATURAL MIGRATION OF URANIUM AND ITS DECAY PRODUCTS: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 230-36, 5 figs., table, Geneva, United Nations, 1958, 16 refs.

One of the fundamental purposes of disequilibrium studies is to provide data for the interpretation of the geological and geochemical history of natural radioactive occurrences. This interpretation in turn may aid the geologist engaged in U or Th ore prospecting.

Several key daughter products and U must be determined in order to study disequilibrium in detail. Published radiochemical methods are used for the analysis of the istope abundances of Pa^{231}, Th^{230}, Ra^{226}, Rn^{222}, and Pb^{210}. U is determined by the standard methods of analysis. In rocks which contain primarily the parent or daughter products of the Th^{232} series, Th^{232}, Th^{228}, Ra^{224}, and Bi^{212} are determined. Alpha scintillation measurements are used to resolve the abundances of each isotope present in the Th, Ra, and Bi-Po separates. Repetitive counting measurements are made over periods of a few to several days using automatic instrumentation which does not require the presence of an operator during this period after the counting has been initiated.

Four generalized types of radioactive disequilibrium involving the U series have been found: (1) the deficiency of all daughter products, (2) the deficiency of Th^{230}, (3) the deficiency of U, and (4) the exclusive Ra isotope occurrences. The deficient U and deficient daughter-product types can be subdivided in groups dependent upon the relationships of the abundances of the key isotopes to each other. Comparisons are made for those groups which possess a more favorable relationship for locating U ore deposits with those which indicate the presence of disseminated U occurrences. Exclusive Ra isotope occurrences, which are often very radioactive, do not necessarily indicate the presence of a nearby U ore. If such ore is not readily located, the source of the Ra is usually widely disseminated low-grade U.

The interpretation of disequilibrium data does not always provide a definite conclusion. An illustration is the common question of whether the U migrated out of the rock under investigation or the alternative that the daughter products migrated into the rock. The geologic interpretation of the general trend of migration of U from an oxidized environment to unoxidized ore deposits can often be supported by disequilibrium studies. Examples are shown for several cases where unoxidized U ore was found not too distant from related radioactivity occurrences of lower grade in oxidized environments.

Several samples have been analyzed which indicate that the time relationships can be estimated for the deposition of U. The samples for which the U deposition can be approximately dated must have ratios of Pa^{231}/U, Th^{230}/U, and Ra^{226}/U such that the growth of each of these isotopes from pure U would require approximately the same interval of time. The usual process involved with these dated relationships is U leaching from oxidized host rock and deposition in a reducing environment.

Study of differences between routine radiometric assays and chemical assays for U is discussed, and the possibility pointed out that misleading conclusions may be obtained unless these occurrences are further investigated by radiochemical analyses. --Auth.

1-926. von Gunten, H. R., W. Buser, and F. G. Houtermans. DETERMINATION OF EXTREME Th/U RATIOS IN MINERALS: A RADIOCHEMICAL METHOD FOR DETERMINATION OF THORIUM: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 239-41, 3 graphs, table, Geneva, United Nations, 1958, 9 refs.

For age determination of U and Th minerals an accurate measurement of the Th/U ratio is needed, especially when accessory Pb is present. The correction of accessory Pb may be made on the basis of the isotope Pb^{208}. It is therefore necessary when determining very low contents of Th in U minerals very exactly to have a measure for radiogenic Pb^{208} The quantitative determination of Th in minerals by chemical methods is rather laborious. The proposed radiochemical method reduces the chemical separations to a minimum. The principle of the method - earlier proposed as ThB/RaD method by one of us - consists in an analysis of the decay curve of the Pb fraction. After dissolution of the mineral, all Pb is extracted by the dithizone method. The extracted Pb is measured in liquid counter tubes. After decay of short-living RaB, AcB, and daughter products, the radioactivity increases, until equilibrium of ThC and ThB is attained. Then the radioactivity is determined during 3 to 48 hours by ThB + C + C". In case of very low Th/U ratios ($<10^{-3}$), the solution was extracted twice with inactive Pb as carrier. The second extraction of the same solution, after growth of ThB, allows an accurate measurement of ThB and therefore of the Th content in the solution. The disturbing effect of RaE is in this way reduced by the ratio of 0.5 days to 30 years. With about 1/g. of U in the solution, Th can be determined down to a ratio Th/U $\sim 10^{-4}$. The method is also practicable for high Th/U ratios. It is evident that the method is restricted to Th and U minerals in complete radioactive equilibrium. --Auth.

1-927. Khitarov, N. I., E. V. Rengarten, and N. E. Lebedeva. CHEMICAL COMPOSITION OF LIQUID INCLUSIONS IN ICELAND SPAR AND GENETIC PROBLEMS: Geochemistry [Geokhimiya], 1958, no. 3, p. 269-78, 3 illus., diag., graph, 3 tables, 2 refs.

Relatively large liquid inclusions in perfect iceland spar crystals from various deposits of the Siberian shield connected with trap formation have been investigated. In the majority of cases the liquid inclusions have calcium-sodium-chloride composition. The salt concentration in a number of inclusions is high. In one of the inclusions, the salt concentration was found to be 230 g./l. In all the solutions, Ca predominates over Na. pH of the solution of one of the inclusions was found to be equal to 5-5.5.

The absence of free CO_2, considerable chloride concentration and the dominance of calcium chloride in inclusions indicate the specific conditions of the formation of the Siberian shield deposits. The conditions of iceland spar crystal formation have been considered on the basis of mineral paragenesis and certain experiments. --Auth.

1-928. Savul, M. A., and V. V. Pomirleanu. THE STATISTICAL METHOD OF DETERMINING THE HOMOGENIZATION TEMPERATURE OF LIQUID INCLUSIONS; MEASUREMENTS OF THE TEMPERATURE OF CRYSTALLIZATION OF QUARTZ FROM SOLUTIONS: Geochemistry [Geokhimiya], 1958, no. 3, p. 259-68, 8 graphs, 4 tables, 6 refs.

The authors apply the law of large numbers to the interpretation of the data obtained from numerous determinations of apparent temperature. They have utilized the method of homogenization of liquid-gas phases of the inclusions from the quartz crystals of various occurrences. The histograms and the frequency curves represented give the possibility to appreciate the frequency maxima and the variation limits of the crystallization temperature in the same quartz crystal or in different points of the same deposit; they permit also some conclusions about the geothermal gradient of the ascending hydrothermal solutions. --Auth.

8. MINERALOGY AND CRYSTALLOGRAPHY

See also: Structural Geology 1-844; Geochemistry 1-902, 1-903, 1-909, 1-910, 1-927; Mineral Deposits 1-985, 1-986, 1-1029, 1-1037.

1-929. Azároff, Leonid V., and Martin J. Buerger. THE POWDER METHOD IN X-RAY CRYSTALLOGRAPHY: 342 p., approx. 125 figs. incl. illus., diags., graphs, tables, New York, McGraw-Hill Book Company, Inc., 1958, refs.

The aim of this book is to present a complete exposition of the theory and practice of x-ray diffraction procedures applicable to polycrystalline materials. Since the principles of this method are independent of the means used to record diffraction spectra, the authors limit their discussion of detectors to the Debye-Scherrer camera.

Following a brief introduction to x-ray diffraction theory, such practical aspects as camera alignment, choice of radiation, sample preparation, etc., are described. The indexing of diffraction lines by all analytical and graphical methods devised to date for the isometric, tetragonal, hexagonal, and orthohombic systems is taken up next. All steps and procedures are fully illustrated with suitable charts and complete discussions of the mathematical relations. A description of the use of the reciprocal lattice concept in indexing powder diagrams by Ito's method is followed by an outline of a straightforward indexing procedure that can be used whenever the crystal symmetry is not known. The theory of selecting the correct lattice and the reduced cell in that lattice completes this portion of the book. The thorough discussion of several procedures for identifying the composition of unknown powders includes step by step illustrations using a number of actual examples. Similarly, the theory and practice of attaining accuracy is fully discussed and illustrated. The book concludes with a brief survey of the effect that crystallite size, preferred orientation, and crystalline imperfections have on powder diagrams. --L. V. Azároff.

1-930. Cullity, B. D. ELEMENTS OF X-RAY DIFFRACTION: 514 p., approx. 300 figs. incl. illus., charts, secs., diags., graphs, 22 tables, Reading, Massachusetts, Addison-Wesley Publishing

Company, Inc., 1956, refs.

This is a textbook designed for the reader who has no previous knowledge of the subject. It is divided into 3 main parts: fundamental theory, experimental methods, and applications. In the experimental section, the diffractometer (the newest instrument in this field) is described in considerable detail, so that the user will know how the various kinds of counters and associated circuits operate.

More than half the book is devoted to applications: determination of single-crystal orientation, measurement of preferred orientation in polycrystalline aggregates, determination of simple crystal structures, precise lattice parameter measurements, stress measurement, study of phase diagrams and of order-disorder transformations, crystal-size measurement, chemical analysis (for phases) by diffraction, and chemical analysis (for elements) by fluorescence and absorption. The book should therefore be useful to metallurgists, chemists, physicists, ceramists, mineralogists, etc., who wish to use x-ray diffraction for the kind of problems mentioned.

The entire book is written in terms of the Bragg law, although a brief treatment of the reciprocal-lattice approach is included in an appendix. Space-group theory, the rotating crystal method, and the determination of complex crystal structures are only briefly mentioned, inasmuch as these topics are outside the scope of this book.--Auth.

1-931. Rowland, R. A., A. J. Weiss, and D. R. Lewis. APPARATUS FOR THE OSCILLATING-HEATING METHOD OF X-RAY POWDER DIFFRACTION: Am. Ceramic Soc., Jour., v. 42, no. 3, p. 133-38, illus., diags., graphs, March 1959, 7 refs.

An apparatus for obtaining the x-ray powder diffraction pattern of a sample while its temperature is increasing at a constant controlled rate has been developed. This equipment is described in enough detail to permit duplicate construction. The program controller is continuously sensitive to the sample temperature and controls the amount of power supplied to the sample heater. Complete schematic details of the electronic circuitry are included, and mechanical details of the program generator are illustrated photographically. The dehydration of clays and related minerals is discussed to illustrate the use of this versatile apparatus. The first-order diffraction maxima of water-wet vermiculite and monoionic Na, Ca, and Mg montmorillonites are recorded while the sample temperature is increased at the rate of 5°C. per minute. This is then repeated with ethylene glycol substituting for water. The temperatures of dehydration and of deglycolation depend on the nature of the exchange cation and are shown to increase in the order Na < Ca < Mg.--Auth.

1-932. Mandarino, Joseph A. ABSORPTION AND PLEOCHROISM: TWO MUCH-NEGLECTED OPTICAL PROPERTIES OF CRYSTALS: Am. Mineralogist, v. 44, no. 1/2, p. 65-77, 3 figs., table, Jan./Feb. 1959, 24 refs.; also pub. as: Michigan, Univ., Dept. Mineralogy, Contr. no. 229.

Certain fundamental relationships of absorption and pleochroism are presented to stimulate interest in the quantitative expression of these 2 properties. The absorption coefficient (k) is given preference as the absorption constant, while biabsorption is reemphasized as a quantitative expression for pleochroism. Methods for the determination of the absorption coefficients are briefly discussed. Two methods for the determination of biabsorption are presented in detail.--Auth.

1-933. Frondel, Clifford, and Alice D. Weeks. RECENT PROGRESS IN THE DESCRIPTIVE MINERALOGY OF URANIUM: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 277-85, table, Geneva, United Nations, 1958, 63 refs.

The paper is divided into 3 main parts. The first part broadly reviews our knowledge to date of the descriptive mineralogy of U and Th. This material is put into historical context with developments in the chemistry, geochemistry, economic geology, and utilization of U and Th. The discussion emphasizes point of view, methods of investigation, and contributions from different countries rather than being concerned with descriptive details. Particular reference is made to the leading reference works currently available in this field.

The second part of the paper presents in tabular form a summary of the descriptive mineralogy of U and Th emphasizing those new minerals described in the past few years. The table includes the name, composition, and crystal system of each U and Th mineral of species status (a few important synonyms and varietal names are cross-referenced), together with a reference to the definitive description of each mineral. Further, a reference is given to the latest x-ray powder data, crystal-structure data, or synthesis study if this information has been published supplementary to the definitive description. Very brief statements are made in footnotes for minerals that need further work in some important regard. The list includes roughly 75 species that are definitely described in reference works and in addition about 20 species that have been described in the periodical literature since the publication of these works. This section also contains a brief characterization in crystallochemical and geochemical terms of the mineralogical expression of U and Th in the lithosphere. A discussion will be included on the occurrence of U and Th as vicarious constituents in solid solution in minerals that do not normally contain these elements.

The third part of the paper discusses the leading problems remaining in the descriptive mineralogy of U and Th. This discussion bears on both specific needs in the way of factual data on particular minerals and groups of minerals, and on the need for new types of information, such as infrared studies, required for the resolution of broader problems. Reference is made to research projects currently under way in various laboratories, including work on the structure of the hydrated uranyl oxides, the synthesis and phase relations of the uranyl silicates, the mineralogy and synthesis of the uranyl sulfates, and the hydrothermal synthesis of uraninite. This section of the paper closes with a discussion of problems of international cooperation in mineral nomenclature, exchange of study material, and coordination of research.--Auth.

1-934. Polikarpova, V. A., and Z. L. Ambartsumian. NEW DATA ON URANIUM MINERALS IN THE USSR: In: International Conference on the

Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 286-309, 29 figs. incl. illus., photomicrographs, graphs, 31 tables, Geneva, United Nations, 1958, refs.

New U minerals are described, namely: uramphite ($NH_4(UO_2)[PO_4]. 3H_2O$), natro-autunite ($Na_2(UO_2)_2[PO_4]_2. 8H_2O$), sodium uranospinite ($(Na, Ca)(UO_2)_2[(AsP)O_4]_2. 5, 2 H_2O$), arsenuranylite ($Ca(UO_2)_4[AsO_4]_2[OH]_4. 4H_2O$), arsenuranocircite ($Ba(UO_2)_2[AsO_4]_2. 8H_2O$), calcium uranomolybdate ($Ca(UO_2)_3[MoO_4]_3[OH]_2. 8H_2O$), barium uranophane, calcium ursilite ($2CaO. 2UO_3. 5SiO_2. 9H_2O$), and magnesium ursilite ($2MgO. 2UO_3 5SiO_2. 9H_2O$), as well as U-containing minerals: U-Mo black powder, U-containing powellite and arshinovite (a metacolloidal variety of zircon).

The results are given of chemical, x-ray, and thermal analyses of nenadkevite and crystallochemical formulas for its black and yellow varieties.

A powdergram has been obtained for hydrogen otenite $H_2(UO_2)_2/PO_4/_2. nH_2O$, which pointed to its complete analogy with synthesized hydrogen otenite.

The mineral of the coffinite type, found in association with sulfides as lens-shaped bodies among granites, differs from the well-known coffinite by the presence of not only quadrivalent, but also of hexavalent U, as well as by the presence of rare earths (Y and Yb), Ca, and Mg.

The regularities of phase transformations in the course of heating phosphates, arsenates, sulfates, sulfate-carbonates, and other uranyl compounds are described. --Auth.

1-935. Coleman, Robert G. THE NATURAL OCCURRENCE OF GALENA-CLAUSTHALITE SOLID SOLUTION SERIES: Am. Mineralogist, v. 44, no. 1/2, p. 166-75, graph, 4 tables, Jan./Feb. 1959, 17 refs.

A study of the sulfides associated with the V-U deposits of the Colorado Plateau has revealed that a complete natural solid solution series exists between galena (PbS) and clausthalite (PbSe). Twenty analyzed samples range in composition from 0.04 to 93.7 molecular percent PbSe in PbS with a concomitant variation of the unit cell from 5.930 Å to 6.127 Å. A plot of these values using the a_o = 5.936 Å for PbS and a_o = 6.140 Å for PbSe indicates an almost straight line variation of the cell edge between galena and clausthalite. Mineragraphic and x-ray study shows these minerals to be true solid-solution phases; exsolution of one end member in the other was not found. Semiquantitative spectrographic analyses indicate that the minor elements in these sulfides are similar to those found in galena with some variations resulting from the environment of deposition. --Auth.

1-936. Hess, H. D., and H. J. Trumpour. SECOND OCCURRENCE OF FERSMITE: Am. Mineralogist, v. 44, no. 1/2, p. 1-8, 2 illus., 4 tables, Jan./Feb. 1959, 5 refs.

Fersmite, $(Ca, Ce, Na)(Cb, Ti, Fe, Al)_2(O, OH, F)_6$, occurs as small anhedral inclusions and intergrowths with a Ta-free columbite occurring in Ravalli County, Montana. Chemical and crystallographic data, along with the physical and optical properties, agree in general with those given in the original description of fersmite from the Ural Mountains of Russia. X-ray diffraction data, not given in the original description, and more specific optical data have been determined. --Auth.

1-937. Hutton, C. Osborne. MANGANOMOSSITE RESTUDIED: Am. Mineralogist, v. 44, no. 1/2, p. 9-18, illus., 2 tables, Jan./Feb. 1959, 16 refs.

Manganomossite from Yinnietharra, Western Australia, is metamict columbite with UO_2 = 0.96%. The untreated mineral with density = 6.17 and R.I. = 2.27, gives weak, diffuse powder and single crystal patterns with relatively few lines or spots, but after being heated in vacuo at 800°C. or at 1,200°C. for periods of 3/4 hour, the density of the mineral showed an increase to 6.32 in each case, and powders prepared therefrom yielded identical but strong patterns with numerous lines, although some diffuseness remains in the high 2θ region. This x-ray pattern may be indexed for an orthorhombic unit cell with the following dimensions: a_o = 5.09 Å, b_o = 14.31 Å, c_o = 5.725 Å, but it is not possible to index the films on the basis of tetragonal symmetry. Autoradiographs show that zonary distribution of radioactivity may or may not be present, but the mineral appears to be free from radioactive centers or inclusions.

A complete analysis of the mineral after elimination of water leads to the formula: $(Mn, Fe, U, Th)_{3.97}(Nb, Ta, Ti)_{7.99}O_{24}$. --Auth.

1-938. Buttler, F. G., L. S. Dent Glasser, and H. F. W. Taylor. STUDIES ON $4CaO. Al_2O_3. 13H_2O$ AND THE RELATED NATURAL MINERAL HYDROCALUMITE: Am. Ceramic Soc., Jour., v. 42, no. 3, p. 121-26, 2 illus., diag., graph, 3 tables, March 1959, 14 refs.

Single-crystal x-ray and electron-diffraction studies show the existence in one polymorph of $4CaO \cdot Al_2O_3 \cdot 13H_2O$ of a hexagonal structural element with a = 5.74 a.u., c = 7.92 a.u. and atomic contents $Ca_2Al(OH)_7 \cdot 3H_2O$. These structural elements are stacked in a complex way, and there are probably 2 or more polytypes as in SiC or ZnS. Hydrocalumite is closely related to $4CaO \cdot Al_2O_3. 13H_2O$, from which it is derived by substitution of CO_3^{2-} for $2OH^- + 3H_2O$ once in every 8 structural elements; similar substitutions explain the existence of compounds of the types $3CaO. Al_2O_3. CaX_2 \cdot xH_2O$ and $3CaO. Al_2O_3. CaY. xH_2O$. On dehydration, $4CaO. Al_2O_3. 13H_2O$ first loses molecular water and undergoes stacking changes and shrinkage along c. At 150° to 250°C., $Ca(OH)_2$ and $4CaO. 3Al_2O_3. 3H_2O$ are formed and, by 1000°C., CaO and $12CaO. 7Al_2O_3$. The dehydration of hydrocalumite follows a similar course, but no $4CaO. 3Al_2O_3. 3H_2O$ is formed. --Auth.

1-939. Dietrich, Richard V., and John W. Murray. A PECULIAR TYPE OF CAVE GYPSUM: Natl. Speleol. Soc., Bull. no. 20, p. 25-30, 4 figs. incl. 2 photomicrographs, table, Nov. 1958, 6 refs.

Extremely fine-grained platelets (parallel to 001) of gypsum have been found to occur in Dunford Cave, Wythe County, and Pig Hole Cave, Montgomery County, Virginia. X-ray patterns obtained by any method except the sphere-mount method present d values equal to those of "typical" gypsum but with notable differences in intensities of many reflections - especially noteworthy are the intensity reversals for d = 3.08 Å and d = 2.89 Å. Differential thermal analyses are significantly different from those of "typical" gypsum - this may be dependent upon the inability to prepare "typical" gypsum with

the same size and crystallographic versus shape orientation as that of the peculiar form. Optically, the peculiar type has a smaller 2V than most gypsum. Solution and reprecipitation promotes conversion of the 001 platelets to gypsum with the common fishtail-twin habit. Association of these gypsum platelets with guano may indicate that the type is formed through reactions involving organisms. --Auth.

1-940. Smith, James P., and Walter E. Brown. X-RAY STUDIES OF ALUMINUM AND IRON PHOSPHATES CONTAINING POTASSIUM OR AMMONIUM: Am. Mineralogist, v. 44, no. 1/2, p. 138-42, table, Jan./Feb. 1959, 9 refs.

Lattice constants and space groups are reported for several complex iron and aluminum phosphates containing potassium or ammonium: $H_6(K, NH_4)_3 Al_5(PO_4)_8 \cdot 18H_2O$ (taranakite), $H_2(K, NH_4)(Al, Fe)(PO_4)_2 \cdot H_2O$, $H_2(K, NH_4)(Al, Fe)(PO_4)_2$, $(K, NH_4)(Al, Fe)_2(PO_4)_2(OH) \cdot 2H_2O$ (leucophosphite), and $H_8(K, NH_4)(Al, Fe)_3(PO_4)_6 \cdot 6H_2O$. A new formula given for taranakite is consistent with the chemical composition, density, and space-group requirements. In a layer structure postulated for taranakite, aluminum phosphate sheets are separated by water molecules. --Auth.

1-941. Bates, Thomas F. MORPHOLOGY AND CRYSTAL CHEMISTRY OF 1:1 LAYER LATTICE SILICATES: Am. Mineralogist, v. 44, no. 1/2, p. 78-114, 5 figs. incl. illus., diags., graphs, 8 tables, Jan./Feb. 1959, 44 refs.; also pub. as: Pennsylvania State Univ., College of Mineral Industries, Contr. no. 57-81.

Sixty-four chemical analyses of sheet structure silicates with a 1:1 type layer lattice have been evaluated in order to demonstrate certain interrelationships between chemistry, structure, and morphology within and between the following mineral groups: kaolin, serpentine, and "other 1:1" layer lattice silicates (amesite, cronstedtite, and ferrous and ferric chamosite). The analyses of 5 synthetic 1:1 compounds and 7 representative chlorites are also included and discussed.

The morphological characteristics of the minerals relate directly to the nature and amount of cation substitution in tetrahedral and octahedral sheets, and to the amount of H_2O+. The former is evaluated in terms of a morphological index, M, which gives a measure of the amount of misfit of the 2 sheets within the layer. The effect of the latter is shown in ternary composition diagrams.

Structural formulas are computed on the basis of a lattice of 18 oxygens but using the premise that oxygen and (OH) allocation between the 2 sheets will be proportioned in accord with the cation distribution. The allocation of cations, in turn, is based on the assumption that substitutions or additions of Fe''' and Al in the octahedral sheet will equal substitutions of these ions for silicon in the tetrahedral sheet.

The kaolin, serpentine, and "other 1:1" groups differ from each other chiefly with respect to the amount of cation substitution and therefore the amount of misfit of the 2 sheets in the 1:1 layer. In terms of the morphological index, serpentines range from +73.53 to +60.09, other 1:1 from +35.35 to -60.09, and kaolins from -72.11 to -84.13.

Within the serpentine and kaolin groups cation substitutions play an important role but the amount of hydrogen provides the most important distinction between platy and tubular varieties. Analyses of chrysotile and halloysite ($2H_2O$) contain significantly more H_2O+ than those of their platy counterparts. Although the position of the "excess" hydrogen and oxygen ions in or on the lattice is not known, the effect of these elements is apparently to weaken interlayer bonds to the extent that misfit of the sheets produces tubes or curved laths rather than plates.

The evaluation of the chlorite analyses yields results similar to those obtained for amesite, chamosite, and cronstedtite in that cation substitution provides for much less misfit than in kaolins or serpentines, and H_2O+ is nearly equal to or less than that to be expected in the O and (OH) of the properly proportioned structural formulas. --Auth.

1-942. Gillery, F. H. THE X-RAY STUDY OF SYNTHETIC Mg-Al SERPENTINES AND CHLORITES: Am. Mineralogist, v. 44, no. 1/2, p. 143-52, 2 graphs, 3 tables, Jan./Feb. 1959, 14 refs.; also pub. as: Pennsylvania State Univ., College of Mineral Industries, Contr. no. 57-55.

The effect of the hydrothermal conditions of synthesis on the production of the Mg-Al chlorite and the serpentine polytypes has been examined. The results show that temperature has the greatest effect on which mineral is produced and composition the greatest effect on which of 3 serpentine polytypes is produced.

The stability relations of the serpentines and chlorites are discussed. --Auth.

Hydrothermal experimentation, by V. G. Hill.

1-943. Bloss, F. Donald, Ebraham Shekarchi, and H. R. Shell. HARDNESS OF SYNTHETIC AND NATURAL MICAS: Am. Mineralogist, v. 44, no. 1/2, p. 33-48, 7 figs., 6 tables, Jan./Feb. 1959, 10 refs.

The hardness of synthetic fluorphlogopite and of 2 natural muscovites, as measured on (001) by the Knoop indentation method, is definitely anisotropic. In both types of mica, maximum hardness is observed when the long axis of the indentation parallels the b-axis, minimum hardness when it parallels the a-axis. The pattern of the anisotropy shows, within the limits of measurement, a bilateral symmetry with respect to the (010) plane. Additional minima also occur on either side of the a-axis at an angle of 60° thereto for muscovite but at 75° thereto for fluorphlogopite. Additional maxima for hardness were observed at about 45° to the b-axis, not at 60° as had been expected. The anisotropy is interpreted in terms of the ionic structure of the micas involved.

Knoop hardnesses were measured parallel to the a and b axes for synthetic fluorphlogopites in which the following substitutions had been effected: (1) ferric and B ions respectively into the tetrahedral Al positions, (2) Mn and Co respectively into the octahedral Mg positions, and (3) Ba and Se into the K positions. The B mica was slightly softer, and the Ba mica was much harder than the normal fluorphlogopite. The Knoop hardnesses of natural phlogopite, muscovite, margarite, and biotite were compared with those of the synthetics. The lesser hardness of these natural micas (excluding margarite) in comparison with the synthetic fluormicas is postulated to result, at least in part, from the greater polarizability of (OH) ion than of F ion. --Auth.

1-944. Wyllie, P. J. DISCREPANCIES BETWEEN OPTIC AXIAL ANGLES OF OLIVINES MEASURED OVER DIFFERENT BISECTRICES: Am. Mineralogist, v. 44, no. 1/2, p. 49-64, 5 figs., 4 tables, Jan./Feb. 1959, 12 refs.; also pub. as: Pennsylvania State Univ., College of Mineral Industries, Contr. no. 57-85.

More than 100 measurements of 2V were made on forsteritic olivines from 2 picrite sills in Soay, Scotland, using both double and single axis conoscopic methods. The mean of double axis measurements agrees closely with the mean of single axis measurements, but a significant difference exists between the means of double axis measurements made over different bisectrices. Measurements of $(-)2V_\alpha$ are smaller than $(-)2V_\gamma$ by about 2.5°. The difference can be explained if the recorded angles are smaller than the true angles when high radial angles are measured on the universal stage, and calculations show that refraction and displacement of light within the central layers of the sphere could produce this effect. Optical measurements of minerals with 2V near 90° may be unreliable unless corrections are made for the errors introduced by the high angles of tilt which are involved in the measurements. --Auth.

1-945. Bonatti, Stefano. CHEVKINITE, PERRIERITE, AND EPIDOTES: Am. Mineralogist, v. 44, no. 1/2, p. 115-37, 12 figs. incl. illus., diags., graphs, 2 tables, Jan./Feb. 1959, 15 refs.

The relationship between perrierite and chevkinite and between these and the epidotes are here reexamined and illustrated on the basis of new data obtained by Jaffe, Evans, Jr., and Chapman on a chevkinite in New Hampshire. --Auth.

1-946. Wada, Koji. ORIENTED PENETRATION OF IONIC COMPOUNDS BETWEEN THE SILICATE LAYERS OF HALLOYSITE: Am. Mineralogist, v. 44, no. 1/2, p. 153-65, graph, 7 tables, Jan./Feb. 1959, 10 refs.

Drying hydrated halloysite from certain salt solutions results in reversible lattice expansion ranging from 5 to 45% of the basal spacing. The reaction occurred with K^+, NH_4^+, Rb^+, and Cs^+, whose ionic diameters are of the order of 2.7 Å or more, whereas smaller cations such as Li^+ and Na^+, and divalent cations Mg, Ca, and Ba gave no evidence of the reaction. The increase in the basal spacing of halloysite is clearly related to the kind of anion. There was no evidence of this type of expansion for montmorillonite. About 200 to 300 m. mols. of the ionic compound were estimated to be retained on the basal plane surfaces per 100 gm. of the air-dried clay.

It is concluded that the cation and anion penetrate between the silicate layers of halloysite, probably forming a unimolecular layer of the ionic compound, replacing the interlayer water. --Auth.

9. IGNEOUS AND METAMORPHIC PETROLOGY

See also: Structural Geology 1-841; Mineral Deposits 1-987, 1-991, 1-1041.

1-947. Maldonado-Koerdell, M. EL VOLCAN BARCENA EN LA ISLA SAN BENEDICTO, ARCHIPIELAGO DE LAS REVILLAGIGEDO (MEXICO) [THE VOLCANO BARCENA ON THE ISLA SAN BENEDICTO, ARCHIPIELAGO DE LAS REVILLAGIGEDO (MEXICO) (with English summ.)]: Ciencia, v. 18, no. 7/8, p. 114-23, 5 illus., map, table, Nov. 1958.

Barcena Volcano was born ... on Aug 1, 1952, and its height reached 1,200 ft. above sea level in 12 days through the rising of a pumitic cone, while part of its eruptive activity was of the nuée ardente type. After the formation of a plug in the crater, through a lateral fissure on the southeastern slope of the volcano, a lava delta was extruded, and except for some few fumarolic emissions, all activity had ceased, and a strong erosional process had begun by the end of 1953. Barcena volcano as well as other semi-destroyed volcanos in San Benedicto Island are considered parasitic craters of an older volcano, Mt. Villalobos, on its northern tip, from which all are separated by an intrusive dike of latite-monzonite. --Auth. summ.

1-948. Scull, B. J. SIGNIFICANCE OF DIASPORE AT MAGNET COVE, ARKANSAS: Science, v. 129, no. 3352, p. 835, March 27, 1959, 8 refs.

The Magnet Cove magmas developed essentially monometallic phases during the later stages of crystallization. The finding of diaspore indicates that an Al-rich phase was present. Ba- and Ti-rich phases have already been reported. --Auth.

10. SEDIMENTARY PETROLOGY

See also: Mineral Deposits 1-986, 1-994, 1-1004, 1-1017; Fuels 1-1053.

1-949. Gorsline, Donn S., and K. O. Emery. TURBIDITY-CURRENT DEPOSITS IN SAN PEDRO AND SANTA MONICA BASINS OFF SOUTHERN CALIFORNIA: Geol. Soc. America, Bull., v. 70, no. 3, p. 279-90, 6 figs. incl. charts, graph, secs., pl., March 1959, 22 refs.; also pub. as: Los Angeles, Univ. Southern California, Allan Hancock Found. Sci. Research, Contr. no. 232.

The floors of San Pedro and Santa Monica basins off southern California lie at a depth of nearly 1000 m. Yet they contain layers of clean sand interbedded with normal deep-water green muds. The sands and their associated beds of silt and of fine gravel are believed to have been rapidly deposited by turbidity currents which started as mass movements at the shallow heads of submarine canyons and at the tops of basin slopes. A similar sequence is present in Pliocene sediments of completely filled basins now on land, for which the shales serve as source beds of petroleum and the sandstones as reservoir beds. --Auth.

1-950. McKee, Edwin D., John Chronic, and Estella B. Leopold. SEDIMENTARY BELTS IN LAGOON OF KAPINGAMARANGI ATOLL: Am.

Assoc. Petroleum Geologists, Bull., v. 43, no. 3, pt. 1, p. 501-62, 21 figs. incl. illus., maps, secs., graphs, pl., 10 tables, March 1959, 53 refs.

Systematic bottom sampling in the lagoon of Kapingamarangi Atoll [Caroline Islands] indicates that sediments accumulating there are of 6 principal types, each characteristic of and largely restricted to definite depth limits. These types of sediment form facies belts that encircle the deepest parts (240 ft.) of the approximately 6-by-8 mi. lagoon and, on a smaller scale, extend around each of the patch reefs in the lagoon. The facies belts, from the reef inward toward greater depths, are composed of the following materials: (1) medium-grained calcium carbonate sand formed largely of Foraminifera (Amphistegina madagascariensis and Marginopora vertebralis), (2) fine-grained calcium carbonate sand formed largely of fragments of mollusks, (3) debris from branch corals growing in thickets nearby, (4) accumulations of algal segments of the genus Halimeda, (5) calcium carbonate sand composed largely of a Foraminifera species (Amphistegina lessonii) different from those in shallow water, and (6) calcium carbonate mud.

Mechanical analyses indicate that in areas of shallow water, sediments are progressively finer with depth, and a gradation lagoonward occurs from foraminiferal sand into shell sand, the effect of waves and tides. Below the belt of branch corals, at depths greater than about 90 ft., however, sediments of the 3 inner facies belts show virtually no mixing. Where strong currents from the sea enter the lagoon on its southern side, a silt formed from shell and coral fragments has developed a tongue that projects lagoonward for about a mile and disturbs the pattern of facies belts that normally parallel the peripheral reef.

The abundance of Foraminifera in most of the sediments at Kapingamarangi Atoll permits a quantitative study of their relation to depth of water and to facies belts. Five large species are important foraminiferal constituents of the sediments. Two occur abundantly in shallow waters up to the crest of the peripheral reef, and 3 occur in waters from 100 to 200 ft. in depth. Other Foraminifera from the atoll are much smaller, occur more sparsely, and are much less important as rock formers; collectively they form in most places less than 1% of the volume of a sample. Foraminiferal content of samples from each of the 6 different facies is distinctive. Relations are apparent between the Foraminifera present, the type of sediment, the depth of water, and the amount of wave action.

Quantitative analysis of microfossils in bottom sediments of the lagoon shows that (1) diatoms and sponge spicules are accumulating in greatest numbers in sediments of the relatively deep, quiet water of the center, and are rare in sediments adjacent to the lagoon beaches; (2) microforaminifers are present in all the major sediment facies of the lagoon, but are particularly numerous on bottoms where water is either very shallow or very deep; concentration in deep areas probably is, in part, the result of environmentally induced dwarfing of otherwise larger forms; (3) pollen and spores in the sediments are locally derived, and their extreme scarcity probably reflects the limited number of local source plants; (4) dinoflagellate cysts in the sediments increase in number with depth, and were not found in sediments from water shallower than 150 ft., bathymetric stratification of the adult planktonic forms may be responsible.

Possible factors controlling organisms represented in each facies belt are variations in type of bottom, turbulence, and temperature which control the faunas at various depths, and light may determine the lower limit of the alga Halimeda. Other factors of possible significance such as chemical composition, pH, salinity, and density seem to be similar at all depths represented and probably are not important controls.

Depth-controlled facies belts, or bathymetric zones, comparable with those at Kapingamarangi, are recognized in some ancient sedimentary deposits, especially in rocks of late Paleozoic age. Certain reefs of several Paleozoic systems are believed to be similar in many respects to the peripheral reef and others to the patch reefs of this atoll. --Auth.

11. GEOHYDROLOGY

See also: Geomorphology 1-829, 1-837, 1-838; Geochemistry 1-918, 1-919; Mineral Deposits 1-976, 1-996.

1-951. Cooper, H. H., Jr. A HYPOTHESIS CONCERNING THE DYNAMIC BALANCE OF FRESH WATER AND SALT WATER IN A COASTAL AQUIFER: Jour. Geophys. Research, v. 64, no. 4, p. 461-67, 6 figs., Apr. 1959, 13 refs.

The dispersion of salts produced by reciprocative motion of the salt-water front in a coastal aquifer induces a flow of salt water from the floor of the sea into the zone of diffusion and back to the sea. The head losses that accompany the landward flow tend to lessen the extent to which the salt water occupies the aquifer. --Auth.

1-952. Glover, R. E. THE PATTERN OF FRESH-WATER FLOW IN A COASTAL AQUIFER: Jour. Geophys. Research, v. 64, no. 4, p. 457-59, fig., Apr. 1959, 5 refs.

Formulas are developed for the flow pattern followed by the seaward-moving fresh ground water as it nears a beach. It is found that, under steady flow conditions, a sharply defined interface is formed between the fresh and salt water. Along the interface the pressure of the static salt water, owing to its greater density, is counterbalanced by the pressures which drive the fresh water seaward. The fresh water escapes through a gap between this interface and the shore line. An increase in the flow of fresh water widens the gap. Tidal action causes a diffusion of salt water across the interface. This salt is carried back to sea with the fresh-water flow. --Auth.

1-953. Vineyard, Jerry. THE RESERVOIR THEORY OF SPRING FLOW: Natl. Speleol. Soc., Bull. no. 20, p. 46-50, 2 illus., map, Nov. 1958, 8 refs.

Origin and supply of water for the large springs of Missouri have been sources of speculation. The first recognized entry into the supply system of a large spring occurred in March 1955, at Cave Spring on the Current River, Shannon County. This medium-sized spring ranges in flow from 16,000,000 to 47,000,000 gallons per day. It issues from the

Potosi-Eminence dolomites of Cambrian age. About 300 ft. downstream from Cave Spring is a small cave, Wallace Well, and about one mile north of the spring is a sinkhole called the Devil's Well. The interrelationship of Cave Spring, Wallace Well, and Devil's Well was revealed by exploration, and the cave system is described. Wallace Well and Devil's Well are huge storage reservoirs in the supply system which feeds Cave Spring. They collect water from a wide area and deliver it to the spring by a network of phreatic conduits. The reservoirs serve as settling basins for removing suspended matter from incoming water, as flood control agents, and as storage reservoirs which contribute to spring flow in time of drought. --A. C. Sangree.

1-954. Meyer, Gerald, and Robert M. Beall. THE WATER RESOURCES OF CARROLL AND FREDERICK COUNTIES. THE GROUND-WATER RESOURCES, by Gerald Meyer; THE SURFACE-WATER RESOURCES, by Robert M. Beall: Maryland, Dept. Geology, Mines & Water Resources, Bull. 22, 355 p., 35 figs., 5 pls. (incl. 3 maps in pocket), 37 tables, 1958, 42 refs.

There are records of 479 wells and springs in Carroll County and 792 wells and springs in Frederick County. The locations of the wells are shown on the county maps which are on the scale of 1 in. to 1 mi. The logs of 85 wells are given. The distribution of the rock units is shown on a geologic map of the 2 counties on the scale of 1 in. to 2 mi.

The hydrologic properties of the rock units and the chemical quality of the water are described. The yields of the wells are analyzed with respect to rock type, depth of wells, topographic position, and depth of weathering. The rock types include igneous, gneisses and schists, early Paleozoic quartzites, shales and limestones, and Triassic sandstones and shales. Nearly all of the ground water occurs in unconfined aquifers. Aquifer and well-performance tests are described in 8 of the 32 rock units.

The surface-water section gives stream-flow records of 20 gaging stations. The characteristics of runoff of the streams are discussed with respect to flood flow and average flow. The results of flow-duration and low-flow frequency studies are presented. --J. T. Singewald, Jr.

1-955. McMurtrey, R. G., R. L. Konizeski, Frank Stermitz, and H. A. Swenson. PRELIMINARY REPORT ON THE GEOLOGY AND WATER RESOURCES OF THE BITTERROOT VALLEY, MONTANA, WITH A SECTION ON CHEMICAL QUALITY OF WATER: Montana Bur. Mines & Geology, Bull. 9, 45 p., 12 figs., 2 maps (in pocket), 6 tables, Jan. 1959.

In 1955, a study of the geology and water resources of the Bitterroot Valley was started by the U. S. Geological Survey in cooperation with the Montana Bureau of Mines and Geology.

The Bitterroot Valley is a broad, N.-S.-trending structural trough, lying between the rugged Bitterroot Mountains on the W. and the more subdued Sapphire Mountains on the E. The steep, straight eastern front of the Bitterroot Mountains and the terraces which slope gently downward from the mountains to the broad flood plain of the Bitterroot River are the most prominent physiographic features of the area. The Bitterroot Valley has a fill of more than 1,700 ft. of Cenozoic sediments. Most of the exposed Tertiary sediments are Pliocene, but the older ones may be Oligocene.

Surface-water records show that about 60% of the yearly runoff and inflow to the valley occurs in May and June. Minimum flow may occur in Aug. or Sept. Sustained low flows, generally lowest of the year, occur in Feb. and March. Approximations of total inflow to and outflow from the study area are tabulated for water years 1938 to 1957.

Tertiary sediments are fine grained and yield little water to wells. Quaternary sediments are the most important aquifers in the valley. In general, these sediments are of larger grain size and are better sorted and thus have higher transmissibility and storage coefficients than the Tertiary sediments. About 165,000 acre-ft. of ground water is available for development in the Bitterroot Valley each year.

Forty samples of water from wells and springs and 16 samples of water from streams were collected and analysed to determine the chemical quality of water in the Bitterroot Valley. Virtually all water in the area is of excellent chemical quality. In general, surface waters are softer and contain smaller amounts of dissolved solids than the ground water.

Geologic factors have a definite bearing on the chemical quality of waters sampled. Streams heading in the Sapphire Mountains, which are made up of dense Precambrian argillite, quartzite, and limestone, contain more mineralized water than streams from the granitic Bitterroot Mountains. Water in the Bitterroot River is about twice as mineralized near Florence, at the lower end of the valley, than it is at Darby, at the upper end. --Auth.

12. MINERAL DEPOSITS

See also: Geologic Maps 1-807; Geophysics 1-893 through 1-898; Geochemistry 1-907, 1-908, 1-914 through 1-919, 1-925; Mineralogy 1-934.

1-956. Pryor, Edmund J. ECONOMICS FOR THE MINERAL ENGINEER: 254 p., 19 figs., New York, Pergamon Press, 1958, 41 refs.

This book sets out briefly the basic principles which govern the economics of mineral engineering. Starting with the methods used by the geologist and prospector in locating an ore body, it proceeds to the proving, development, and valuation required to establish the ore reserve and to justify the financing of a mine. Conventional accountancy is dealt with in simple outline, company structure, together with the legal requirements governing Board activities and retention of mining title. The principles and practice of line-and-staff control and management are shown from Board through to the operating labor, and methods of coordination, management, accountancy, cost-analysis, and variance control are discussed. The interlink between the financial and metallurgical balance sheet via systematic collection, collation, and digestion of process data is examined. Managerial ethics, relations with trades unions, plant safety, quality control, operational research, and departmental budgeting are considered. The methods of planning and building the mineral treatment plant are gone into, together with the award and control of contracts, and the

training of new labor in the handling of the new process. Smelter schedules and specifications for selling grades are included in a section on the marketing of products. Among generalities are such matters as the engineer's personal service contracts, the obligations of his professional status, and recommendations for the lucid writing of reports. A glossary of several hundred words defines terms used in the business of mining, processing, managing marketing, and financing ore production. --Auth.

1-957. Solow, Herbert. GEOCHEMISTRY: THE PROSPECTOR'S NEW TOOL: Fortune, v. 59, no. 2, p. 126-29, 176, 178, 182, 184, col. illus., map, Feb. 1959.

The first step in producing anything with a metal component is to find the metal. Yet, the technological revolution that has come to every phase of the metal industry is coming last of all to prospecting. Geochemical methods are an important part in the technological revolution in mineral prospecting.

Basically, geochemical prospectors determine for a given region a normal trace amount of a particular element. They then sample for anomalous amounts of the element, which may or may not lead to an ore deposit. Among deposits so found are: an extension of a known Sb deposit near Ketchikan, Alaska; the Colorado Plateau Yellow Cat U district; Utah's Chief Pb mine extension in the Tintic district; and the Murray Brook, New Brunswick, base-metals deposit; a Cu-Fe deposit in British Columbia; also many foreign deposits.

Geochemical prospecting, tried 1500 years ago in China, and much later developed by Agricola (De Re Metallica, 1556), became an important exploration tool in Soviet mineral exploration under A. E. Fersman in the 1930's. It was also used in Sweden and Finland. The U. S. Geological Survey created the Geochemical Exploration Section at Denver in 1946. This is today, outside the U. S. S. R., the main center of the new prospecting technology.

The use of geochemical methods has been made practical by the development of new testing procedures that can be carried out quickly and economically in the field. These include colorimetry, paper-chromatography, emission spectroscopy, biogeochemistry, and geobotany, and are generally crude but cheap.

Many problems in geochemical prospecting remain unsolved, and results are not always as they might appear. Geochemical prospecting will never be a substitute for geology or geophysics, but it is now and will continue to be an important tool in the prospector's kit. --G. E. Denegar.

1-958. Malyuga, D. P. AN EXPERIMENT IN BIOGEOCHEMICAL PROSPECTING FOR MOLYBDENUM IN ARMENIA: Geochemistry [Geokhimiya], 1958, no. 3, p. 314-37, illus., 5 maps, 2 graphs, 6 tables, 26 refs.

On the basis of studying the Mo distribution in soils and plants of the Kadzharansk ore region (Armenia), it has been shown that Cu-Mo deposits can be easily discovered from the surface by the analysis of soils and plants. The Mo content in the chestnut-colored soils above the ore zone varies from 1.0×10^{-3} to 3.0×10^{-2}% and in the plant ashes from 3.0×10^{-3} to 1.0×10^{-1}%, being many times higher than the usual Mo content.

There is a certain correlation in Mo content between the ore at a depth and the plants (and soils) on the surface. The maps made according to the Mo concentrations in the soils and plants exactly outline the dissemination halo of the new ore zone on the left bank of the Okhcha river. The investigations have proved the efficiency of the biogeochemical prospecting for Mo in Armenia. --Auth.

1-959. Fedorchuk, V. P. ORIGIN OF NATIVE MERCURY: Geochemistry [Geokhimiya], 1958, no. 3, p. 345-52, 5 figs. incl. cross-secs., table, 7 refs.

Large depositions of native Hg have been found in the Khaidarkan deposit [Khaydarken, U. S. S. R.; 39°59'N. 71°20'E.]. A number of facts indicate its hypogene genesis. These facts are: the absolute absence of signs of cinnabar leaching in nearby ore bodies, the position of Hg-bearing lenses in the overlapping shales directly above the richest cinnabar occurrences in the central part of the dome-shaped folded structure, the uniform impregnation with Hg of the surrounding shales, and the composition of admixtures in Hg which is similar to that in cinnabar from the main ore-bearing level and different from the composition of mixtures in supergene Hg. --Auth.

1-960. Goddard, Charles C., Jr. BERKELEY PIT HISTORY AND GEOLOGY: Mining Engineering, v. 11, no. 3, p. 290-92, 2 cross-secs., March 1959.

The Butte district has produced over $2,250,000,000 in Cu, Zn, Mn, Ag, and Au, unprecedented in the mining world. Exhaustion of the Au placers, located in 1864, was followed by Ag-Au mining from many of the vein outcrops. Montana was the leading Ag-producing state in the 1880's. Deeper mining disclosed Cu occurred in abundance. From this beginning Butte became the greatest Cu-producing district in the world. During the first period to 1910, 6,600,000,000 lb. of Cu were produced. At the time of the initiation of the Kelley mine, another 6,600,000,000 lb. of Cu were added, and at the end of 1957, a total of 14,604,000,000 lb. of Cu were produced during Butte's 78-year history.

Deep levels continue to show the same type of Cu mineralization that was found on high levels. This continuing resource and improvements in mining, mechanization, and efficiency allow Butte to continue as an important producer of mineral wealth. The Berkeley, planned to augment production of the deeper mines and the Kelley block cave mine, was made possible as the result of studies of old geologic records and incomplete sampling data. The existence of a supergene enriched sulfide ore body near enough to the surface for open-pit mining was proven by underground sampling crosscuts and extensive churn drilling from the surface. --Auth.

1-961. Fursov, V. Z. HALOS OF DISPERSED MERCURY AS PROSPECTING GUIDES AT THE ACHISAI LEAD-ZINC DEPOSITS: Geochemistry [Geokhimiya], 1958, no. 3, p. 338-44, sketch map, cross-sec., graph, 2 tables, 3 refs.

Some conclusions have been made on the basis of the analysis of 4528 samples taken from various parts of the Achisai deposit [Achisay, U. S. S. R.; 43°35'N. 68°53'E.]. Hg is present in sulfide and oxidized ores in galena, sphalerite, pyrite, cerussite, and smithsonite; its content in these minerals is tens and thousands times higher than its average con-

centration. In the rocks at a distance from the ore bodies, Hg has not been detected by the method used; the sensitivity of the method is 3×10^{-5}%. The presence of Hg dispersion halos on the surface in the epicentres of blind ore bodies deposited at a depth of 25 to 300 m. has been established. The absence of Hg dispersion halos in the eluvium-diluvium can be explained by its dispersion, during hypergene processes, to concentrations which are below sensitivity of spectral analysis. --Auth.

1-962. Boyle, R. W., G. F. Koehler, R. L. Moxham, and H. C. Palmer. HEAVY METAL (Zn, Cu, Pb) CONTENTS OF WATER AND SEDIMENTS IN THE STREAMS, RIVERS, AND LAKES OF SOUTHWESTERN NOVA SCOTIA: Canada, Geol. Survey, Paper 58-1, 31 p., illus., 3 figs. (in pocket), 1958, 18 refs.

A reconnaissance geochemical investigation revealed that both the water and sediments of most streams draining the Southern Upland, North and South Mountains, and the Annapolis Valley carry little heavy metal except locally. This suggests that extensive zones of base-metal mineralization are absent in those parts of Nova Scotia. Higher than normal amounts of metal were, however, noted in stream sediments in a belt paralleling the SE. shore of Minas Basin. These streams all drain the contact between clastic sediments of the Horton group and limestones of the Windsor group, both of Mississippian age. --H. M. A. Rice.

1-963. Kiss, Jean. URANIFEROUS CHROMIUM ORE AND ITS PARAGENETIC ROLE IN THE MECSEK PERMIAN AGGREGATE: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 396-401, photomicrograph, 4 graphs, table, Geneva, United Nations, 1958, 15 refs.

The detrital lower Permian aggregate of Mecsek mountain [Hungary; 46°06'N. 18°13'E.], which varies in thickness and color, can be divided along broad lines in the following order:

a) The lowest part of the aggregate is made up of light-gray sandstone and dark-gray sandstone, mostly without feldspar, but with several pelitic or argillaceous sandstone intercalations.

b) Above are strata, principally psammitic, of a light-green or green color and of considerable thickness, with an increasing feldspar content.

c) Finally, there is arkosic sandstone, with a characteristic red tint and grayish-black pelitic intercalations.

These formations are well-differentiated strata that indicate the horizon, with more or less significant recurrences.

The strata mentioned above form units that can be well defined according to their petrographic-sedimentary character, their association with elements, and their mineralogical composition. The lower part is rich in organic debris, and the average green aggregate is characterized by a high relative frequency of the elements of the Cr and Ba groups, while in the upper aggregate, there is an enrichment of Fe^{+++}, Ca^{++}, and Mg^{++}, with a considerable feldspar content.

In this report, the author discusses the Cr enrichment in the average aggregate called "green aggregate," its geochemical role, and the correlation Cr-U and Cr-V. He also treats in detail the formation and geochemical role of a Cr mineral that is emerald-green in color and of epigenic formation. According to the observations made so far, it is a micaeous mineral of dioctahedral structure, which cannot be identified with either fuchsite, chromium-illite (avalite), or mariposite as known in the literature. It is a mineral of a negative character, with a low value of 2 V. When heated (900-1000°C.), it becomes red, without any great change in structure, and is transformed into a uniaxial mineral with a negative sign.

The green color of the rock is thus due to the micaceous Cr mineral that has been mentioned, which, among the allothogenic constituents in a finely-divided state, forms the principal cement in the rock. This mineral also forms coatings around silicified tree-trunks, and, finally, it fills in the more or less large fissures.

The Cr mineral that has been investigated is not among the important uraniferous minerals (U about 0.026%), but its role as an accumulator of U and its geochemical characteristics serve to clear up the conditions for the enrichment of radioactive elements in psammitic rock. --Auth. summ.

1-964. Carpenter, L. Graydon, and Donald E. Garrett. TUNGSTEN IN SEARLES LAKE: Mining Engineering, v. 11, no. 3, p. 301-303, 2 maps, table, March 1959, 4 refs.

Probably the largest single W deposit in the United States is one that has yet to produce any W; it is not even listed in tables showing U. S. reserves. This deposit is at Searles Lake, California, where the brine contains about 70 ppm. WO_3. Small though this concentration is, the amount of brine in the lake is so great that it is estimated at 170 million lb. of WO_3 (8.5 million units) equalling the total of all other known reserves in the United States. An unexploited reserve promises more W than the total contained in all other known sources in the United States. The problem now is commercial recovery. --Auth.

1-965. Bryzgalin, O. V. THE ORIGIN OF SCHEELITE IN SKARN ORE DEPOSITS: Geochemistry [Geokhimiya], 1958, no. 3, p. 297-304, diag., 4 tables, 6 refs.

Some general geological and mineralogical features of scheelite skarn-type deposits are considered. A suggestion has been made of the possibility of W transfer in skarn ore process with alkaline (essentially Na) solutions. The scheelite deposition is considered to be the result of exchange reaction $Na^{+} \rightleftharpoons Ca^{2+}$ between the hydrothermal solution and surroundings. Some experiments are described on modeling the process of the W transfer and scheelite deposition at the interaction of alkaline solutions containing W with some minerals; the experiments were carried out at temperatures 350-500° and pressures of 250-600 atm. -- Auth.

1-966. Nininger, R. D. GEOLOGIC DISTRIBUTION OF NUCLEAR RAW MATERIALS: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 7-10, graph, Geneva, United Nations, 1958, 6 refs.

Because of numerous changes in the known geologic distribution and type of U resources during the past decade, repeated modifications of U exploration con-

cepts were required. Prior to 1953, vein-type deposits yielded most production, comprised major reserves, and represented the most favorable exploration targets. To discover additional deposits, such as those at Shinkolobwe, Belgian Congo, and Port Radium in Canada, was the major objective of the geologist and exploration engineer. The second most important source of low-cost U appeared to be by-product U from Au mining in South Africa. Only limited potential was assigned to the increasing U reserves in sandstones and associated sedimentary formations.

Discovery of major U deposits in sedimentary rocks in the United States, beginning in 1953, rapidly changed exploration thinking, and such deposits became the major target. Developed reserves in sedimentary rocks and in Precambrian conglomerates, including those not dependent on Au production, have greatly expanded since 1955. Experience since that time has, however, also indicated that vein and similar deposits in igneous and metamorphic rocks have retained their relative importance.

In 1955, approximately 75% of known reserves of low-cost U in countries other than the U.S.S.R. and areas of Soviet influence represented deposits in Precambrian conglomerates. Approximately 15% represented deposits in sedimentary rocks, primarily Mesozoic sandstones and conglomerates. Vein or vein-type deposits in igneous and metamorphic rocks comprised 10%.

Today, although the general distribution of reserves by geologic types remains the same, there are some significant modifications. Total reserves in Precambrian conglomeratic deposits have substantially increased, but now represent only 60% of the total. The proportion of reserves in sedimentary rocks has expanded to 30% and now includes important deposits in Tertiary sediments. The proportion in vein-type deposits remains at 10%.

Because of the widespread occurrence of U deposits in sedimentary rocks and the large areas of sedimentary terrane available for exploration, this type of deposit will probably continue to expand in relative importance and provide the most important source of new reserves.

Vein-type deposits are expected to remain in third place. Significantly, in spite of the large increase in total reserves in all types of deposits, relative importance of this type is not declining. This is important to countries whose exploration possibilities are mainly limited to igneous and metamorphic terrane.

Present information indicates reserves of Th to be smaller than those of U. They have, however, expanded significantly since World War II with the discovery of the vein monazite deposits in the Union of South Africa and the by-product potential of Blind River, Canada. Th reserves appear to be adequate for industrial atomic-energy purposes for many years.

Be reserves are smaller than those of Th, but with proper economic incentive should adequately supply presently foreseen requirements for atomic energy. Extensive placer deposits of zircon appear to be adequate for present commercial and atomic energy requirements for Zr.--Auth.

1-967. Johnson, J. C. RESOURCES OF NUCLEAR FUEL FOR ATOMIC POWER: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 3-6, Geneva, United Nations, 1958.

A vast accumulation of scientific and technical information on U geology, exploration, mining, and milling was presented at the First International Conference on the Peaceful Uses of Atomic Energy at Geneva in 1955. This information gave the world its first comprehensive view of nuclear raw materials available for atomic-energy purposes.

In the 3 years since the First Conference, even more information on nuclear materials has become available. In addition to important new developments in geology, exploration, and metallurgy, data on U ore reserves and production rates have now been made public by many nations, thus permitting the world to better estimate the availability of nuclear fuel supplies and their costs. It is hoped that other countries will follow this example at this conference so that planning for the peaceful applications of atomic energy may be even further advanced. An important consequence of this declassification of information is the increased facility of exchange visits by technicians in the field of raw materials among many of the U-producing countries for training and study purposes. Such opportunities have also been extended to countries now in earlier stages of appraising their own nuclear fuel resources.

Recorded U ore reserves in the United States have more than doubled since the First Conference, and now are estimated to contain 200,000 tons U. Full development of present producing areas may nearly double this figure. Figures released by the Canadian and South African governments indicate U reserves of about 400,000 tons in each of those countries. Reserves in Australia, Belgian Congo, France, Portugal, and other Western Nations may approximate 150,000 tons. Total U reserves in countries other than the U.S.S.R and areas of Soviet influence may therefore be currently estimated at about 1,300,000 tons. This figure represents an increase of about 800,000 tons since 1955. Discovery of an additional 2 million tons of low-cost U is probable in extension of present producing areas and in areas of similar geology.

By 1959, expanded mill facilities in the producing nations of the West will annually produce about 40,000 tons of U_3O_8 concentrate. It is anticipated that the rapid rise in the annual rate of concentrate production will then level off for a number of years.

Exploration in countries with major U reserves has declined appreciably, while new exploration programs are being undertaken by numerous countries which lack significant reserves. Although the present supply situation is favorable, exploration programs will be needed to maintain this position.

Many types and combinations of U recovery circuits are currently in use. Most mills use ion-exchange processes, but liquid-liquid solvent extraction is an alternative process which is becoming increasingly important. Advancement in milling technology has been an important factor in the rapid increase in U production.

The diversity in the size and type of mining and milling operations permits only general statements on average costs. In general, large-scale mining and milling operations, improved methods and techniques, and better recoveries have substantially reduced U concentrate prices which in some large operations are now less than $8 per pound of U_3O_8. It is not anticipated that it will be necessary to resort to high-cost U from phosphates or shales for many years to come.

At the present time, U production is sufficient for all contemplated nuclear power requirements and other peaceful uses. However, future nuclear power programs may require as much as 50,000 to 100,000

tons of U a year by 1970 or 1975. U exploration and development must continue in order to assure an adequate supply. --Auth.

1-968. Everhart, D. L. SUMMARY OF UNSOLVED PROBLEMS AND NEW TRENDS IN URANIUM GEOLOGY: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 310-14, 2 maps, Geneva, United Nations, 1958, 14 refs.

During the past 10 years, a large worldwide literature on the subject of U geology has been built up. Much of this material was summarized for the First International Conference on the Peaceful Uses of Atomic Energy. In general, publications on U geology to date have fallen into the following 4 categories: descriptions of U ore deposits and occurrences, studies of the geochemistry and mineralogy of U, classification of U ore deposits based on associated geologic features, and investigations of the origin and geologic controls of U ore deposits. In all, the major emphasis in the literature has been on a wide array of observed facts concerning U distribution and its multiple associations.

There is considerable evidence that major U deposits are concentrated in certain belts, known as "uranium provinces," in the earth's crust. There are several possible geologic reasons for the distribution of U provinces, but perhaps basically all U provinces are related to Precambrian granitic masses that have, or have had, anomalously high U contents. Paucity of data for this idea is emphasized. Possibilities for undiscovered major U provinces are discussed.

The transport of U has been demonstrated in at least the 4 following categories of geologic processes: magmatism; juvenile hydrothermal solutions; groundwater solutions, both hot and cold, in both ancient and present ground-water systems; and detrital mechanisms.

Of these, perhaps slightly heated ground waters in ancient systems are the most significant, but they are also perhaps the least understood. Much more research is required to define favorable geochemical characteristics of such solutions, from the standpoint of U transportability, the precipitating effects of associated elements, heat and pressure effects, and the effects of varying climatic conditions.

U deposits of significance have been found in virtually every major rock type, with a resultant de-emphasis of the presumed importance of certain so-called "favorable host-rock types."

More quantitative data is required concerning the effect of the following upon the precipitation of U compounds from ore solutions: change in rate of flow, change in pH, change in temperature and/or pressure, carbon "trash," petroliferous matter, and natural gases.

The value of generalization at this time on the origin of U deposits appears to the writer to be open to question in view of the evidence of varying modes of origin among the world's major U districts. There is a growing appeal to the concept of the reworking and "reincarnation" of U deposits as a result of each major tectonic event in geologic history.

It is concluded that: the most favorable U provinces in the world may now be more clearly defined on the basis of information developed in the past 3 years; effective transporting agents for U - whether magmatic, juvenile-hydrothermal, or ground water - may now be better understood; effective precipitants of U may be evaluated; and large areas of the earth's crust have possibilities for containing U deposits of the least moderate size, which may in the future provide well-distributed raw-materials sources for atomic energy. --Auth.

1-969. Kratchman, Jack. REGIONAL EXPLORATION CRITERIA FOR URANIUM: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 325-29, map, table, Geneva, United Nations, 1958, 24 refs.

Future U reserves will undoubtedly be developed by extending individual ore bodies or by exploring favorable areas within U-producing districts. Examples are given which illustrate this type of exploration criteria and future reserve.

In addition to new reserves from producing mines or districts, it is anticipated that other reserves will be developed in areas which lack significant discoveries but contain favorable geologic features.

The location of major U mines or producing areas with respect to major tectonic elements throughout the world indicates that U bears a marked preference for specific, large-scale tectonic elements. Precambrian shield areas contain the greatest percentage of the world's known U. However, large amounts of U are also present in post-Precambrian sedimentary basins, and in orogenic belts not associated with shield areas.

In the Precambrian shields, U is almost invariably related to Archean or Proterozoic geosynclines and mobile belts. In some instances, mineralization may occur in fault or breccia zones within these deformed Precambrian sediments or in associated silicic-alkalic-pegmatitic intrusives. However, the presence of locally exposed intrusives is not essential to the existence of a deposit. For example, uraniferous conglomerates represent a type of deposit in Precambrian geosynclines not directly related to silicic-alkalic-pegmatitic intrusives.

Post-Precambrian basins of sedimentation are becoming increasingly important in the distribution of deposits. Although there are numerous types of basins, closed or "focal" basins formed by subsiding blocks located between folded mountain zones contain the richest U deposits, e.g., Colorado Plateau, U. S. A.; Fergana basin, U. S. S. R.

Granitic rocks intruded in the later stages of geosynclinal development frequently act as host rocks for significant U deposits. Numerous U deposits are located in granites intruded into the Hercynian or Variscan folded structures of central and western Europe. Granitic intrusives are widespread in the Tertiary mountain belts of the world, and some commercial U deposits are related to these intrusives (Prince of Wales Island, Alaska; Spokane, Washington; and Marysvale, Utah). However, the pattern of U distribution in intrusive areas in Tertiary mountain belts is not as well defined as in European Hercynian intrusives.

Based on the concepts developed above, future U provinces are discussed. Among those areas selected as being potentially favorable are regions in the Canadian, Australian, African, and Brazilian shields; the Tarim and Ordos basins, central Asia; the Texas basin, U. S. A.; the Pannonian basin, Hungary; Hercynian or Variscan granites, Europe (Vosges Mountains, France; Odenwald, Germany, Sardina; and Corsica).

Substantial amounts of U have been discovered in geologic environments other than those discussed above, and it is expected that new sources of U will be found in favorable areas similar to Lakeview, Oregon (volcanic host rock); Texas (coastal plain sediments); North and South Dakota (lignites). --Auth.

1-970. Page, Lincoln R. SOME NEW MINERALOGICAL, GEOCHEMICAL AND GEOLOGIC AIDS IN URANIUM EXPLORATION: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 123-25, Geneva, United Nations, 1958.

Recent advances in mineralogy have aided in the recognition and understanding of supergene deposits of black uranium oxides, including some secondarily enriched portions; the recognition of the asymmetric distribution of various minerals on either side of the "roll" ore bodies; and the understanding of the spatial association of iron oxides, carbonates, and silica with U minerals. One of the most useful geochemical techniques applied to the understanding of altered ores is the study of radioactive disequilibrium. The use of Pb-isotype analysis of minerals such as jarosite, limonite, and other secondary minerals as a method of indicating leaching of U with downward migration to unoxidized zones has been suggested. Numerous investigations have been made relative to the origin and migration of materials found in ore in sedimentary rocks. Perhaps the most important new development in prospecting for U in sedimentary rocks is the finding of major deposits in the kind of environments normally considered favorable for the accumulation of petroleum and natural gas. No significant discoveries of U deposits between 1955 and 1958 can be attributed to hydrogeochemistry, but this continues to be of interest as a potential method of finding new and major deposits. --G. E. Denegar.

1-971. Gangloff, A. M., C. R. Collin, A. Grimbert, and H. Sanselme. APPLICATION OF GEOPHYSICAL AND GEOCHEMICAL METHODS TO THE SEARCH FOR URANIUM: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 140-47, 8 maps, Geneva, United Nations, 1958, 8 refs.

Until 1954, the Commissariat à l'Energie Atomique prospecting for U was mainly founded on direct geological surveying and on observation of radiometric data, which were applied to the different stages of the work (preliminary exploration, detailed prospecting, drilling, etc.). Though these methods are still necessary, some others, depending on geophysics and geochemistry, have been for the last 4 years associated with them.

Practical work proved that in the richest French districts, U ore bodies are closely connected with tectonic features. Some various geophysical methods (magnetism, seismic refraction, self-potential, electric logging, and especially all prospecting techniques using direct current) bring, in a given district, precise data on structure (direction, dip, size) and on physical parameters of rocks. These data, when studied and compared, give definite indications on interesting zones, or on the degree of hydrothermal alteration. The reading of these measures could be improved, when necessary, through statistical methods.

Likewise, geochemical prospecting brings data on the distribution of U traces in soils. Specific and direct methods are added to indirect geophysical processes. Measures are given by fluorimetry or chromatography. The sensibility of such a process passes, in many cases, that of radiometric measuring on field.

The study of Rn emanations from soils has also given valuable information.

Whether it be research for the possible extent of an ore body or the evaluation of an occurrence discovered by preliminary surveys, the use of geophysical, geochemical, and radiometric methods make it possible to obtain, without requiring much time, and at rather low costs, the information which is necessary to undertake drilling or mining.

Let us also note that notwithstanding this definite work, geochemistry could be most useful on a large scale for exploration, and particularly to locate interesting zones in large districts. Some essential studies are still necessary, though we sometimes already complete our previous prospecting methods with the measuring of U in waters and in alluvials. --Auth. (transl.).

1-972. Illsley, C. T., C. W. Bills, and J. W. Pollock. SOME GEOCHEMICAL METHODS OF URANIUM EXPLORATION: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 126-30, map, graph, Geneva, United Nations, 1958, 7 refs.

As U discoveries have increased in the United States, the application of geochemistry as an aid to U geology has become more complex. Geochemical research and development projects have been carried on by the Division of Raw Materials, U.S. Atomic Energy Commission, to provide basic information which may be applied to exploration or general studies of U geology. The applications and limitations of various aspects of geochemistry to U geological problems are considered herein. Modifications of existing analytical techniques have been made and tested in the laboratory and in the field. These include rapid quantitative determination of U in water, soil and peat, and of trace amounts of sulfate and phosphate in water.

Radiometric surveys have proven to be the most satisfactory direct technique for U reconnaissance. Hydrogeochemistry has been used as a reconnaissance method, but the general distribution of U and its mobility in nature makes interpretation difficult. Detail and reconnaissance projects covering 100 sq. mi. in the Mt. Spokane area, Washington, and 6,000 sq. mi. in northern Michigan and northeastern Wisconsin are described.

Sediment and rock analyses have been used in conjunction with hydrogeochemistry to study background influences. Sediment analyses, without supporting rock and water analyses, have been investigated as a possible reconnaissance tool in areas having only intermittent streams.

Soil analyses have provided information for detailed work near known deposits. The use of soil analyses to delineate subsurface structures or to indicate migrational trends of U has been demonstrated, but considerably more experience is necessary before economic geologic use can be fully realized.

"Geochemical anomaly" has been defined as a significant departure from the average abundance background of an element where the distribution has

not been disturbed by mineralization. The detection and significance of geochemical anomalies are directly related to the mobility of the element being sought in the zone of weathering. Mobility of U is governed by complex physical, chemical, and biological factors. For U anomalies in surface materials, the chemical factors affecting mobility are the most significant. The effects of pH, solubility, coprecipitation, adsorption complexion, or compound formation are discussed in relation to anomalies detected in water, soil, and stream sediments.

Programing a geochemical project is as important a consideration as the final interpretation of the collected data. Depending upon the individual project, the following questions should be considered. Is the application of geochemistry logical, considering the known geologic environment and mineralization of the selected area? How large and accessible is the area to be covered? What type of coverage is desired - reconnaissance or detailed? What type and what frequency of sampling will be most productive? What is the availability and cost of chemical and physical analyses? What are the most effective and economical procedures? What is the estimate of personnel and man-hours required?

These are general considerations but are discussed specifically as they apply to U and its associated geochemistry. --Auth.

1-973. Murakami, Yukio, Shizuo Fujiwara, Motoo Sato, and Shuji Ohashi. CHEMICAL PROSPECTING OF URANIUM DEPOSITS IN JAPAN: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 131-39, illus., 3 maps, 6 graphs, diag, 6 tables, Geneva, United Nations, 1958, 13 refs.

In Japan, natural waters, soils and rocks, and plants have been selected as the objects for the chemical prospecting of U deposits. The following 2 methods (direct and indirect) have been used.

The [first] one, called a direct method, consists in the fluorimetric determination of U contents in these samples and finding out the possibilities of the occurring location of the U deposit.

U in aliquot amount of the sample is coprecipitated to concentrate with aluminum phosphate and then, after dissolving the precipitate with nitric acid, is extracted with ethyl acetate. For example, in natural waters, a sample is taken from the station at suitable intervals (preferably 20 m. intervals as for the detailed survey) along a rivulet on the surveying area. 500 ml. of the sample is used for each determination.

The residue obtained by evaporating the extract is melted with flux (a mixture of sodium fluoride, sodium carbonate, and potassium carbonate). Then, to determine the U content the intensity of the fluorescense in 555 mμ wave length emitted from the cake, when activated with ultraviolet light, is measured with the transmission-type fluorimeter. This apparatus was devised by the laboratory of the Atomic Fuel Corporation of Japan. Thus, the detecting limits of U is formed as 0.1 g. /liter of water sample.

The [second] one is called the indirect method, because U occurrence is indirectly [determined] through the results of some elements other than U - say Zn, phosphate, Mo, and V, etc. - in these samples. In this study the author has found that Zn and phosphate have a close relation with the occurrence of U.

Minute amounts of phosphate are colorimetrically determined by comparing the color due to the Mo blue which is developed with the reducing action of stannous chloride. When its content is lower than 0.1 g. /liter of water sample, the Mo blue is extracted with a mixed solvent of isopropyl ether, chloroform, and butyl alcohol. By this extraction method, it is easy to determine minute amounts of phosphate as 0.01 g. /liter.

The content of Zn is also colorimetrically determined by using carbon tetrachloride solution of dithizone. One ml. of this solution is equivalent to 5 or 10g. Ag. And the detecting limits of Zn is 1g. / liter of the water sample.

From the standpoint of the geological conditions of the area [under the consideration] and depending upon the circumstances whether the general or the detailed survey is required, we have sometimes used both methods and at other times either of the 2 separately.

The results obtained at Ningyô-tôgé U district will be reported giving a consideration on the occurrence of U deposits. Through these results we may conclude as follows:

The natural waters and other samples taken from the neighboring area and its closely related area of the U deposits have shown high anomaly in contents of U, PO_4^{3-}, Zn, etc. Therefore, the prospecting work using these methods will be fruitful for the discovery of U deposits and the assumption of the scale or the promising area. Among them, water samples are most convenient and most helpful for these purposes, because we can usually find that the area for prospecting in Japan has enough rivulets to obtain the successful result.

Moreoever, it is reasonable to expect that these methods will give much more results on this problem if used in connection with some other exploration methods. --Auth.

1-974. Jedwab, J. ADAPTATION OF PAPER CHROMATOGRAPHY TO GEOCHEMICAL PROSPECTING FOR URANIUM DEPOSITS OF THE KATANGA TYPE: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 178-81, Geneva, United Nations, 1958, 2 refs.

In the geochemical prospecting for U deposits of the Katanga type, which contain many metals, it is necessary, at times, to make a determination of traces of Cu, Co, and Ni in the soil, in addition to that of the U. Some methods of paper chromatography developed in the past by Hunt, North, and Wells in particular) enable us to make a determination of these elements quite rapidly in field laboratories, far away from the main centers.

However, it is impossible, according to the techniques in general use, to carry out the determination of the 4 elements of interest in the same initial solution, which makes it necessary that the same soil sample be digested twice, once for the U determination and another for the Cu, Co, and Ni determination. This circumstance is attended with considerable loss of time, which immediately reflects on the economy and speed of prospecting.

By resorting to a simple modification of the customary techniques, it proved possible to draw up an analytic scheme for the successive determinations of U, then of Cu, Co, and Ni, by means of a single digestion, in a double boiler, by dilute nitric acid, which gives a solution containing the main part of the elements sought, and lending itself to an immediate determination of U.

After the amount of solution needed for this determination has been drawn, concentrated hydrochloric

acid is added to the remainder, which makes it possible to proceed with the Cu-Co-Ni determination.

The chromatographic separation of these 3 elements is as good as that achieved by the method of Hunt, North, and Wells. The Rf values for Cu and Ni remain the same, but that of Co is slightly smaller.

Several hundreds of samples of African soils have been analyzed for their content in the 4 elements by following the analytic scheme which has been described. [One hundred and fifty to 200] determinations of U-Cu-Co-Ni can be made every day, starting from dried and screened soils.--Auth. (transl.).

1-975. Smith, G. H., and T. R. D. Chandler. A FIELD METHOD FOR THE DETERMINATION OF URANIUM IN NATURAL WATERS: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 148-52, table, Geneva, United Nations, 1958, 13 refs.

A simple method has also been developed for field use in geochemical prospecting. It is based upon the formation, at a pH of about 6, of the yellow-colored uranium dibenzoylmethane complex which is extracted from the water sample with carbon tetrachloride. The organic phase is separated from the water, and its color intensity compared visually with that of a set of standards. In this way it is possible to detect amounts of U down to 1 μg. U_3O_8. The dibenzoylmethane is added to the water sample as a 0.5% w/v solution in a 1:1 v/v pyridine-water mixture containing 0.6% w/v ethylenediaminetetra acetic acid (disodium salt) to complex interfering metallic ions. Ascorbic acid is also added to the water sample to eliminate the interference otherwise caused by ferric iron. It was found that many waters contained organic matter that caused emulsification and orange-brown colors in the carbon tetrachloride layer. To remove this interference, several types of adsorbent material were examined including silica gel, activated alumina, kaolin, precipitated manganese dioxide, and several grades of activated charcoal. Of these, certain grades of activated charcoal proved to be the most satisfactory. The adsorbent is added to the acidified water sample which is then filtered and neutralized with alkali before proceeding with the method. It was found that the addition of 2% v/v of silicone fluid to the carbon tetrachloride helped to prevent emulsification, as does the addition of sodium chloride to the aqueous phase.--Auth.

1-976. Hecht, Friedrich, Heinrich Küpper, and Walter E. Petrascheck. PRELIMINARY REMARKS ON THE DETERMINATION OF URANIUM IN AUSTRIAN SPRINGS AND ROCKS: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 158-60, geol. map, 6 tables, Geneva, United Nations, 1958.

U content of water (1 to 12 ppb.) in the Vienna basin, especially that of springs occurring along a tectonic fault system, was compared with the U content (0.5 to 2.3 ppb.) of the tributaries of the Danube river and of the streams and rivers of the Waldviertel. Investigations also indicate that waters originating from the Bohemia massif are essentially poorer in U (0.5 to 1.6 ppb.) than those from the sedimentary areas of the northern Alps.

At Silz, at the northern edge of Ötztal-Stubai Alps gneiss, 38 ppb. U was detected. Water from coal seams near the base of the upper Carboniferous at Franzstollen contain 21 ppb. U. Some brines of the Vienna basin contained up to 60 ppb. in certain areas.

Lignite from the upper Tertiary of Trimmelkam proved to be particularly uraniferous (some hundreds ppm. U in ashes). But radiometric surveys showed only local occurrences of U in lower seams. Coal deposits of Statzendorf and Langau, resting on Bohemian massif crystallines, showed no significant radioactivity. Bauxite from Unterlaussa contains U and V minerals. Well-bedded Cretaceous black shales covering this bauxite contain approximately 70 ppm. U.--G. E. Denegar.

1-977. Adler, H. H. APPLICATION OF ISOTOPIC DATA TO PROBLEMS OF URANIUM GEOLOGY: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 224-29, table, Geneva, United Nations, 1958, 30 refs.

Isotopic fractionation is the result of chemical and physical changes which enrich the abundance of one isotope of an element with respect to another. Both radiogenic and nonradiogenic elements show isotopic variations which can be attributed to reactions in geological processes. The determination of the isotopic ratios of certain elements has resulted in considerable data from which various natural processes can be inferred. Particular attention has been focused on the nuclides of low atomic weight such as H, He, B, C, O, Si, and S, which exhibit readily measurable variations owing to their high mobility. Cu, Pb, and U also have been studied in some detail, the latter 2 because of their importance as geologic clocks.

In considering the ultimate objectives of geochemical prospection for U, it is important to focus some attention on those factors which suggest profitable application of isotope chemistry to exploration. Foremost, perhaps, is the separation of radiogenic nuclides during natural processes. Second is the ubiquitous nature of certain substances such as pyrite and carbonaceous material in sedimentary deposits and the coexistence of U with these materials. Finally, in the absence of measurable anomalous radioactivity, geochemical isotopic methods would offer distinct advantages in exploration. Attention has been directed recently toward obtaining information relative to the isotopic variation of Pb as an indicator in U exploration.

U in outcrops is subject to leaching under conditions of continued or renewed weathering, and eventually all U may be removed leaving largely in place the less soluble radiogenic nuclides and Pb. The ideal geochemical behavior of those nuclides which are fairly long-lived is predictable to some extent; nevertheless, more fundamental information on their geochemical cycles is essential to intelligent utilization in prospection.

Extensive research on the $C^{12/13}$ and $S^{32/34}$ isotope distribution in nature has indicated significant trends in diverse selected occurrences with which U is frequently associated. It would now seem possible to compare the isotopic ratios of pyrite associated with U and carbonaceous materials, such as petroliferous residues, asphaltite, and fossiliferous and coalified wood, and derive some insight.

Alternative hypotheses include: (1) U emplacement by circulatory ground water devoid of a magmatic source and at ordinary ground water temperatures, (2) leaching from pre-existing lean U sources in stratified ash accumulations, and (3) contemporaneous

deposition, either accompanying the emplacement of the original strata, or shortly after.

The circulatory ground-water hypothesis would deny the significance of alteration criteria, much mineralogical data, the evidence of urano-organic ores, certain features of regional distribution, and widespread igneous activity. The ash-leach hypothesis ignores these criteria, and in addition fails repeatedly to consider stratigraphic distribution. The hypothesis of contemporaneous deposition appears even less tenable. It overlooks the evidence of alteration, urano-organic ore, absolute-age data, mineralogical data, igneous activity, and the wide range in vertical distribution. Each hypothesis may apply under special local conditions, but widespread application to explain original U emplacement is doubtful.

While constantly accumulating data favor the hydrothermal theory, many features remain to be established. Further refinement and additional evaluation of all available criteria are desirable. However, the importance of the interpretation of the mechanism of introduction to the long-range program of U exploration emphasizes the value of the solution of this problem. --Auth.

1-978. Cannon, R. S., Jr., L. R. Stieff, and T. W. Stern. RADIOGENIC LEAD IN NONRADIOACTIVE MINERALS: A CLUE IN THE SEARCH FOR URANIUM AND THORIUM: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 215-23, 3 figs., Geneva, United Nations, 1958, 29 refs.

Isotopic analysis of Pb from non-radioactive minerals may provide a useful clue in the search for U and Th. Many of the analyzed samples of sulfide minerals from U and Th mining districts contain Pb that is distinctive in isotopic composition compared with sulfides from districts producing other metals. The recognition of such isotopically distinctive radiogenic Pb in galena, pyrite, or other non-radioactive ore minerals may be used as a helpful criterion in exploration for new U districts, or in searching for U or Th in established metal-mining districts. The detection of radiogenic Pb in non-radioactive minerals, however, should not be regarded as a self-sufficient exploration technique, although evidence of this kind may suggest proximity of U or Th in areas where other evidence has not been recognized.

The isotopic composition of Pb in ore deposits is much less uniform than the isotopic composition of other common ore metals. Observed variations are in part a function of the istopic evolution of Pb. Throughout geologic time the radiogenic Pb created by radioactive disintegration of U and Th ($U^{238} \rightarrow Pb^{206}$, $U^{235} \rightarrow Pb^{207}$, and $Th^{232} \rightarrow Pb^{208}$) systematically augments the earth's supply of Pb and dilutes the nonradiogenic isotope Pb^{204}. The evolutionary additions of radiogenic Pb^{206}, Pb^{207}, and Pb^{208} can easily be seen by expressing the isotopic abundances as multiples of Pb^{204}. For example, galena from an extremely old Precambrian ore deposit may contain Pb with ratios Pb^{206}/Pb^{204} = 12.6, Pb^{207}/Pb^{204} = 14.2, Pb^{208}/Pb^{204} = 32.7, whereas, Pb in a relatively young (e.g., Tertiary) ore deposit is more likely to have ratios such as 18.7, 15.6, 38.8. Pb from many ore deposits is intermediate in composition between the above values, but noteworthy departures from the systematic evolution of Pb are observed in some localities. In Th provinces, Pb may be perceptibly enriched in the Th-decay product Pb^{208} - in the Blind River area of Canada Pb^{208}/Pb^{204} ratios range from 36.2 to 81.9. In many U districts, Pb in sulfides commonly is enriched in the U-decay products Pb^{206} and Pb^{207}. For example, the ratios Pb^{206}/Pb^{204} and Pb^{207}/Pb^{204} in Pb minerals from the Colorado Plateau range from 18.5 and 15.4 in the least enriched samples to 1193.0 and 78.4 in a galena highly enriched in radiogenic Pb. In still other U or Th districts, no evidence of radiogenic enrichment in Pb minerals has yet been found, as, for example, in the uraninite veins of the Colorado Front Range.

Pb that is notably enriched in Pb^{206} evidently has been associated with U, in some geologic environment, past or present, in abnormal ratio. Such Pb has been found in sulfide minerals from a number of U districts where deposits occur in clastic sedimentary rocks, in a number of U districts where uraninite occurs in veins, and in a single uraninite vein within a major non-ferrous metal-mining district. Discovery of such Pb in non-radioactive ore minerals in a locality where U deposits are not known may thus serve as a clue to justify an intensive search for U in that vicinity. --Auth.

1-979. Chervet, Jean, and R. Coulomb. GEOCHEMICAL BEHAVIOR OF URANIUM IN THE ALTERATION CYCLE: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 199-203, 5 tables, Geneva, United Nations, 1958, 5 refs.

The investigation of the genesis of secondary mineralized accumulations and the prospecting of deposits from microchemical anomalies in the surface material, requires a well-developed knowledge of the geochemical properties of U during the alteration phase.

In the present work, the authors tried to track the U history during a part of natural migration:

a) They describe some most typical mineralogical observations of alteration phenomenon and material migration, picked up in place in the deposits.

b) They give experimental results concerning the solubilities of the U minerals and the factors affecting this solubility.

c) They study water circulation in granitic batholiths, and the influence of the occurrence of the U deposits on their composition.

d) They observe the amplitude of phenomena restricting the dispersions: fixations, precipitations, etc., and growth behavior in uraniferous areas.

e) Finally, the opposition: chemical alteration-radioactive equilibrium results in an important disequilibration in altered materials. The authors tried to use the measurement of this disequilibration to explain geochemical processes. --Auth. (transl.).

1-980. Mingarro, E., and F. Catalina. THE GEOCHEMICAL PROCESS OF ALTERATION OF PRIMARY URANIUM ORES AND THE ELECTRON MICROSCOPIC STUDY OF THESE ORES: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 204-10, 6 photomicrographs, graph, table, Geneva, United Nations, 1958, 9 refs.

In order to determine the relationship of the minerals which are a product of alteration processes and predominant in the Spanish deposits with the pitchblendes considered to be the primary minerals

and their mutual dependence, we are trying a method based on a differential geochemical study of the pitchblendes and uranium phosphates, through a quantitative spectrochemical analysis of the chemical elements which are associated with the U in minute quantities.

These geochemical associations persist in the hydrolysates, since the co-existence of the oligo-elements of pitchblende can be shown in the surface waters. An Fe-Cu-V and Ag-U diagram is drawn up, which shows, for each zone or geochemical group, the hydrothermal origin of the abnormalities in the U content.

By resorting to electronic microscopy, we made a study of the elemental forms of the precrystalline and amorphous states of pitchblende in the various phases which intervene in its deposition. Use is made of the C replica technique on suspensions of particles of the mineral about 1 or 2 microns in size and the etched surfaces of polished preparations. --Auth. (transl.).

1-981. Shcherbina, W. V. GEOCHEMISTRY OF URANIUM IN THE OXIDATION ZONE OF ORE DEPOSITS ON THE BASIS OF EXPERIMENTAL STUDY DATA: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 211-14, fig., Geneva, United Nations, 1958.

Investigations of geochemical processes in the oxidation zone of ore deposits and reproduction of these processes by experiment made it possible to reveal the nature of chemical reactions which account for the formation of U minerals in the oxidation zone of ore deposits.

Superposition of the later geochemical processes on the products of the earlier processes, their stage development, and the resulting mineralogical zonality are observed.

The reactions proceeding in the oxidation zone of U ore deposits are as follows: hydrolysis, ionic exchange resulting in hardly soluble compounds; oxidation-reduction reactions; formation and destruction of complex compounds; sorption processes. The nature of these reactions depends on humid or arid type of weathering. Examples of reactions that account for paragenesis of exogenous U minerals and their connection with endogenous mineralization are given in the paper. --Auth. (transl.).

1-982. Kushnarev, I. P., L. I. Lukin, B. L. Rybalov, E. P. Sonyushkin, and L. V. Khoroshilov. GENERAL LAWS GOVERNING THE LOCALIZATION OF URANIUM MINERALIZATION AND THE BASIC TYPES OF STRUCTURES OF HYDROTHERMAL URANIUM DEPOSITS: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 315-24, Geneva, United Nations, 1958.

The structural types of ore bodies described... do not exhaust the diversity of natural conditions of localization of U ores in hydrothermal deposits. However, the data adduced... show that the structural conditions of the localization of U deposits and ore bodies do not differ in principle from those of the hydrothermal deposits of other metals formed in similar geological conditions. --Auth. concl.

1-983. Rafalsky, R. P. THE EXPERIMENTAL INVESTIGATION OF THE CONDITIONS OF URANIUM TRANSPORT AND DEPOSITION BY HYDROTHERMAL SOLUTIONS: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 432-44, 17 figs. incl. illus., photomicrographs, diags., graphs, 5 tables, Geneva, United Nations, 1958, 33 refs.

The investigations were carried out in accordance with the up-to-date concept on the transport of hexavalent U under hydrothermal conditions and its precipitation as a result of reduction.

The study of the stability of sodium uranyl-tricarbonate showed that it is decomposed with precipitation of uranates at temperatures of about 100°C.

It has been found that hexavalent U is reduced by hydrogen sulfide both in acid sulfate and carbonate solutions at elevated temperatures.

In carbonate solutions, U is reduced even at room temperature. In this case, the reaction proceeds in a neutral or even slightly acid medium in the presence of H_2S and CO_2.

In excess of H_2S the reaction results practically in complete reduction of hexavalent U.

At an elevated temperature and pressure U is reduced and precipitated from uranyl-sulfate solutions by pyrite, chalcopyrite, galena, siderite, hornblende, or organic components of carbonaceous shales. The end product of the reduction is usually crystalline uraninite.

The data obtained testify to the possibility of hexavalent U being transported by hydrothermal solutions and deposited as a result of reduction process. At the same time, the values of solubility of freshly precipitated uranium dioxide at elevated temperatures determined experimentally make it possible to assume that under hydrothermal conditions U could migrate in its tetravalent form as well. --Auth. (transl.).

1-984. Nekrasova, Z. A. THE FORM OF THE OCCURRENCE OF URANIUM IN SOME COALS: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 412-19, 11 figs. incl. illus., photomicrographs, graphs, 4 tables, Geneva, United Nations, 1958, 12 refs.

According to the prevailing theory concerning the forms in which U occurs in caustobioliths, U is found in coals mainly in the form of uranyl humates or other U organic compounds.

The study of the U-bearing coals made by the author has shown that these coals contain U partly in the form of typical oxides (pitchblende and U black powder) and partly in the finely dispersed form, which defies microscopic identification.

A heavy residue rich in U has been extracted from the coals having finely dispersed form of mineralization by using supercentrifuge. X-ray analysis of this residue showed that these coals contain U mainly in the form of oxides.

The ratio of coal ash and U content, regularly increasing U content in highly oxidized coal varieties, and some other data give additional proof of the assumption that U occurs in coals mainly in the oxide form. --Auth. (transl.).

1-985. Bates, Thomas F., and Erwin O. Strahl. MINERALOGY AND CHEMISTRY OF URANIUM-BEARING BLACK SHALES: In: International Conference on the Peaceful Uses of Atomic Energy, 2d,

Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 407-11, 2 figs., 2 tables, Geneva, United Nations, 1958, 4 refs.

Samples (1185) representing 11 black shale formations from various parts of the United States and Europe have been analyzed by mineralogical, chemical, and radiometric techniques. From a mineralogical standpoint, although there are important quantitative differences, all the shale samples are qualitatively similar except those from the St. Hippolyte district of France which contain siderite instead of calcite as one of the major constituents. The French shales also contain abundant metaautunite, but most of the U in these samples and all of the U in the other shales is loosely held in the fine-grained organic-inorganic matrix of the rock. Except for the metaautunite, there is no evidence of any U mineral.

The 787 bituminous shale samples from the Chattanooga, Ohio, Woodford, and Alum shales show a carbon-log U correlation of +0.89. The carbonaceous Kansas, Allegheny, and St. Hippolyte shales deviate markedly from this, largely as a result of the greater degree of oxidation which is reflected primarily in the amount of free Fe and carbonate present. When this and the other compositional factors are taken into account by multiple regression analysis, the association of composition with log U for all shales except those of St. Hippolyte improves 7.5% (from R^2 = 79.2 to 85.5). The regression equation showing the relationship of the major components to U is as follows:

$$\log (U \times 10^4 + 1) = 1.8081 - 0.2045 \text{ (free Fe)} - 0.0400\ CO_2 + 0.0140 \text{ (pyrite)} + 0.0465 \text{ (organic carbon)} - 0.0076 \text{ (silicates)}.$$

Using this equation, the U content of any black shale which belongs to the same population as those evaluated herein, and has not been substantially enriched or leached after deposition, can be calculated from the measured amounts of the major constituents of the rock. In shales like that of St. Hippolyte the amount of post-depositional U will be approximately equal to the difference between the measured and the amount calculated by the above formula. --Auth. summ.

1-986. Strahl, Erwin O. AN INVESTIGATION OF THE MINERALOGY AND PETROGRAPHY OF URANIUM-BEARING SHALES... AN INVESTIGATION OF THE RELATIONSHIPS BETWEEN SELECTED MINERALS, TRACE ELEMENTS AND ORGANIC CONSTITUENTS OF SEVERAL BLACK SHALES: U. S. Atomic Energy Comm., [Pub.] NYO-7908, 155 p., 18 figs. incl. diags., graphs, 11 tables, July 1958 pub. 1959, 96 refs.

The relationships between and among the mineral, organic, and trace-element constituents of samples of the Chattanooga and the Ohio shales in the United States, the St. Hippolyte of France, and the Alum shale of Sweden have been investigated and discussed in terms of the geochemical environments. The relative importance of the environmental factors was evaluated.

A total of 280 samples were analyzed for total C, organic C, aliphatic and aromatic hydrocarbon, carbonate, total Fe, iron oxides, pyrite, total silicates, quartz, kaolinite, illite, amorphous silicates, U, Mo, Mn, and quartz grain size.

The methods for the analysis of the hydrocarbons, the silicate minerals, and Mo and Mn were developed or improved by the writer in order that suitable quantitative data could be obtained.

The amounts of aromatic and aliphatic hydrocarbons obtainable from a shale by CS_2 extraction were determined by nuclear magnetic resonance spectroscopy.

The amounts of quartz, kaolinite, illite, and amorphous silicates were determined by first roasting and acid leaching the samples and then obtaining x-ray diffractometer tracings.

The Mo and Mn were quantitatively determined by using a method which combined the advantages of solution-spark and mutual standard emission spectroscopy.

The data obtained were analyzed using correlation and factor analysis statistics.

The more important relationships made obvious by this investigation are as follows:

Pyrite, organic C, and U vary together in the shales studied and depend upon reducing conditions for their concentration.

Mo and Mn co-precipitate in an environment characterized by the presence of carbonate minerals. The presence of carbonate is a reflection of the oxidative environment necessary to precipitate these elements.

In a highly reducing environment, organic C and carbonate are incompatible but in a more oxidizing environment the enrichment in organic C is paralleled by an enrichment in carbonate.

In the marine shales investigated, the amount of illite relative to the amount of kaolinite is much greater than in the continental shale.

A well-defined negative relationship between illite and amorphous silicates in the marine shales, and a poorly-defined negative relationship between kaolinite and amorphous silicates in the continental shale, was found. In both the marine and continental shales, such relationships are considered to be a function of the rate of deposition.

As the amount of quartz in the sediment increases, the maximum quartz grain size also increases, but the increase in grain size for a given increase in amount is more rapid in the continental shale than in the marine shales.

The redox environment is the most important factor in the deposition of black shales. The rate of deposition appears to be highly interrelated with the redox environment in those cases where the rate of deposition was relatively rapid.

As shown by the relationship of aliphatic to organic C, the organic material is uniform in character in the bituminous shales and somewhat more variable in the carbonaceous shales.

On the basis of this study, it is concluded that the compositions of the shales investigated are highly dependent on the geological factors of environment. The redox potential; the nature of the basin of deposition, marine or continental; and the rate of deposition apparently control the mineralogical and chemical compositions of the black shales. The nature of the organic material, bituminous or carbonaceous, appears to be related to both the type of material available and to the oxidation of the sediment during deposition.

These geological factors are interrelated and the composition of a shale is the result of the joint action of these factors during deposition. --Auth.

1-987. Bondam, J., and H. Sörensen. URANIFEROUS NEPHELINE SYENITES AND RELATED ROCKS IN THE ILIMAUSSAQ AREA, JULIANEHAAB DISTRICT, SOUTHWEST GREENLAND: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 555-59, 6 figs., incl. illus., maps, table, Geneva, United

Nations, 1958, 14 refs.

Concentrations of radioactive minerals are found in the eudialyte-bearing nepheline syenites of the Ilimaussaq complex in SW. Greenland.

The radioactive minerals may occur in 3 different ways: (1) as accessories in the melanocratic nepheline syenite, called lujavrite. The lujavrite is considered to be the youngest rock of the complex, in which it occupies a considerable volume. The U content averages about 150 ppm. In restricted areas concentrations of 500 to 2000 ppm. have been found. The Th content is 2 to 7 times that of U. Detailed studies of high-grade lujavrite occurrences have been carried out during the last few years and are still in progress; (2) as local concentrations in inclusions of older, recrystallized nepheline syenite in the lujavrite; (3) as concentrations in recrystallized zones of deformation in some of the oldest nepheline syenites of the complex.

Only the lujavrite may be considered as possible low-grade U and Th source; the other occurrences are mainly of genetical interest.

The most important radioactive mineral is steenstrupine, with about 0.3% U and 2.7% Th. Steenstrupine may alter to various poorly-defined radioactive alteration products. Monazite, britholite, microlite, and thorianite have been found in small amounts. The eudialyte of the nepheline syenites is faintly radioactive. Steenstrupine is found in rocks, in which the eudialyte has been altered hydrothermally. --Auth.

1-988. Griffith, J. W., A. H. Lang, S. C. Robinson, S. M. Roscoe, and H. R. Steacy. TYPES AND ORE RESERVES OF CANADIAN RADIOACTIVE DEPOSITS: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 35-39, map, 2 tables, Geneva, United Nations, 1958, 5 refs.

This paper provides summarized figures for production of U in Canada and for reserves of radioactive ores. Restrictions on publication of such data were removed recently. The paper also provides a revised classification and short discussion of geological types of productive and non-productive radioactive deposits, thus serving as an introduction to the more detailed papers submitted... Tons are short tons of 2,000 pounds (0.9 metric tons).

Production of uranium oxide in Canada in 1957 [was estimated to total 6,687 tons valued at $136,700,000]. This was 3 times the production of 1956 because operation of several large new mines was begun. At the end of 1957, 15 mines having their own treatment plants were in operation, and 8 smaller mines shipped ore to some of these plants. All are in the Precambrian shield, and ores of 3 greatly different types are mined. In the Blind River region, Ontario, quartz-pebble conglomerate whose matrix contains U and Th minerals accounted for 51% of the Canadian production. Pitchblende-bearing veins and disseminations in Beaverlodge region, Saskatchewan, and Great Bear Lake and Marian River regions, Northwest Territories, provided 41%. Dikes and lenses of pegmatitic granite in Bancroft region, Ontario, yielded 8%.

U and Th, or both, have been found in Canada in several other types of deposits. Some of these offer large tonnages of material lower in grade than the ores now being mined. Others occur in small deposits and appear to be mainly of scientific interest. The non-producing types are: granitic rocks and pegmatites of kinds other than those yielding ore at Bancroft; metasomatic deposits; unconsolidated placers; sandstone carrying autunite; dolomite containing monazite and (?) uraninite; phosphate rock; and uraniferous carbonaceous deposits in shale, lignite, and sandstone.

Ore-reserve figures supplied by companies have been compiled according to types of deposits and classes of reserves. "Measured ore" is material that is thoroughly blocked out and sampled. "Indicated ore" is fairly well blocked out and sampled, but some continuity based on geological evidence is assumed. "Inferred ore" is partly revealed and sampled, but considerable continuity based on geological evidence is inferred. Total reserves are estimated at 377,000,000 tons, chiefly in the "indicated" class.

The conglomeratic deposits are estimated to contain about 356,000,000 tons to a maximum depth of 1150 m. (3700 ft.). These figures agree well with an independent calculation made by the Geological Survey, which yielded an estimate of 320,000,000 tons, including only beds 3 m. (10 ft.) or more in thickness; this excluded the Pronto deposit which is in a separate part of the district but which is included in the larger total. The conglomeratic ores average about 0.1% U_3O_8. Pegmatitic deposits in production or being prepared are estimated to contain about 11,000,000 tons averaging about 0.1% U_3O_8. Pitchblende deposits now in production are estimated to contain about 8,650,000 tons; these range in tenor from about 0.2 to 0.5% U_3O_8, most averaging about 0.2%. In addition, the Rexspar deposit, which has some of the characteristics of a hydrothermal deposit, is estimated to contain 1,719,000 tons containing about 0.1% U_3O_8. Considerable additional ore of the kinds and grades now being mined but not included in the estimates is probably present, as parts of some producing deposits lying beyond the limits set for "inferred ore," and at partly explored prospects.

Much potential "ore" below the grades now considered economic has been partly proved at producing properties and elsewhere.

Low-grade Th deposits are know to occur in large tonnages, particularly at Blind River. The ores of this region as a whole, although not sampled for Th as exhaustively as for U, are estimated to average about 0.05% ThO_2; some very large deposits average about 0.1% ThO_2, and certain ores carry 0.2 to 0.3% ThO_2. The ores now being mined for U at Bancroft are reported to carry about 0.02 to 0.2% ThO_2, and material with still higher content is said to be available. --Auth.

1-989. Robinson, S. C., and D. F. Hewitt. URANIUM DEPOSITS OF BANCROFT REGION, ONTARIO: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 498-501, geol. map, Geneva, United Nations, 1958, 5 refs.

U deposits of the Bancroft region of southeastern Ontario include pegmatitic granite dikes, pegmatites, metasomatic deposits, and calcite-fluorite-apatite veins. Only deposits belonging to the pegmatitic granite class have thus far been worked commercially. These are the only deposits of the general pegmatitic class from which U is being produced in Canada. Two mines with plants of 900 tons (1,000 short tons) of ore a day are producing, and a third is scheduled to begin production in 1958. Another mine is shipping ore.

Most of the deposits occur in Faraday, Cardiff, and Monmouth townships in an area extending 40 km. in a southwesterly direction between Bancroft and Tory Hill. This region contains 3 major batholiths which are mantled by variably granitized paragneiss and lime-rich metamorphic rocks. A few of the U deposits occur within the batholithic complexes, and a few others are remote from them, but most, including all the major deposits, lie in the rocks mantling the batholiths.

Principal radioactive minerals in the deposits are uraninite and uranothorite. In the granitic deposits, zircon is abundant, and its distribution is similar to that of U minerals. Virtually all deposits contain calcite and fluorite in minor but significant amounts. The ore bodies are fairly large and have average U contents greater than has usually been demonstrated for pegmatitic deposits. The grades are of the order of 0.1% U_3O_8 and from 0.025 to 0.2% ThO_2. Recent studies have indicated that the most favorable factors are probably structural position and competency and chemical composition of wall rocks. --Auth.

1-990. Roscoe, S. M., and H. R. Steacy. ON THE GEOLOGY AND RADIOACTIVE DEPOSITS OF BLIND RIVER REGION: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 475-83, 3 figs. incl. illus., maps, graphs, table, Geneva, United Nations, 1958, 15 refs.

The U deposits near Blind River, Ontario, are in beds of pyritic quartz-pebble conglomerate near the base of a sequence of Precambrian sedimentary rocks called Huronian; these unconformably overlie granitic rocks, gneisses, and greenstone. The basal Huronian formation, evidently derived from an extensive pre-Huronian surface covered with residual detritus, consists of grit, pebbly arkose, feldspathic quartzite, and quartz-pebble conglomerate. The lithology varies greatly from place to place. Primary sedimentary structures indicate that the formation was deposited and sorted by streams that flowed from NW. to SE. The formation shows pronounced local variations in thickness aligned to the SE. The thicker parts apparently overlie valleys on the pre-Huronian surface. Most of the U ore lies within 2 such valley-like structures whose central parts contain the most numerous, closest spaced, thickest, and most radioactive conglomerate beds.

The Huronian rocks have been folded into a broad anticline and syncline that trend E.-W. and pitch gently to the W. The anticlinal axis lies about 16 km. S. of the synclinal axis. The 2 main ore zones are on opposite flanks of the syncline; a third containing a single mine, Pronto, is on the S. limb of the anticline. There are numerous faults in the area. The Huronian rocks, only slightly metamorphosed, are cut by dikes and sills of diabase. No important relationships can be discerned between radioactive conglomerates and secondary structures, metamorphism, proximity to igneous rocks, or to mineral deposits of other types.

The ore deposits most typically constitute only a part (determined by sampling) of a thick, poorly-defined zone of conglomeratic rocks within the lower 50 m. (150 ft.) of the basal formation. The deposits themselves consist of numerous intercalated lenses of quartz-pebble conglomerate, conglomeratic quartzite, and pebble-free quartzite. Although the deposits show remarkable continuity and fairly uniform average grade, individual lenses within them vary greatly in U content and generally cannot be followed far.

Principal ore minerals are brannerite, uraninite, and monazite, typically occurring as small individual grains within the matrix of the conglomerate, with abundant pyrite. At least 22 other minerals have been recognized in ores; several are radioactive, and most are minerals that commonly occur as heavy accessories in igneous rocks.

Data on the U-Th content of different rock types are presented. Ratios of Th to U in most quartzites and conglomerates are similar to ratios in older granitic rocks to the NW. The lowest ratios of Th to U (as low as 0.1) are found in ore conglomerates along central parts of the ore zones and represent a high proportion of U-rich minerals (uraninite and brannerite) to Th-bearing minerals (chiefly monazite). In ore zones, ratios commonly show wide differences in individual lenses. There is, however, a general increase of ratios in successively higher conglomerate beds upward through the basal formation. Ratios also increase laterally toward and beyond the boundaries of ore zones. These and other data when carefully studied in relationship to the very complex stratigraphy of the basal formation may show systematic variations in the mineralogy of the radioactive conglomerates which can be related to variations in the velocities of paleocurrents.

The deposits are believed to be placers that contained radioactive minerals, and which were subsequently altered with introduction of at least part of the sulfur. It is not yet certain whether uraninite and brannerite as now present were original detrital constituents. --Auth.

1-991. Mawdsley, J. B. THE RADIOACTIVE PEGMATITES OF SASKATCHEWAN: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 484-90, map, Geneva, United Nations, 1958, 24 refs.

The first discoveries of pitchblende veins in Saskatchewan were made on the N. shore of Lake Athabasca in 1935, and production from these started in 1953, while the first uraninite-bearing pegmatite was found on the N. shore of Lac La Ronge, near the S. boundary of the Precambrian shield, 13 years later in 1948. Since then, with the aid of the geiger counter and scintillometer, these radioactive pegmatites and migmatite (mixed rock) zones have been found in widely separated districts from the northeastern section of the province to near the S. boundary of the Precambrian. Although high assays have been obtained and sizable tonnages of marginal material have been indicated, none of these bodies are of present commercial value, although the treatment of the ore promises to be simple and relatively inexpensive. However, it will be surprising if a continued search and a fuller knowledge will not uncover in this vast, partially explored area deposits of this nature of commercial importance.

These radioactive pegmatite and migmatite zones are the end phase of a great period of granitization and igneous action that ended approximately 1,800 million years ago. Related to them are numerous non-radioactive dikes. The dissimilarity between the 2 types seems to be due either to structural differences or to chemical differences in the intruded wall rocks.

The coarse-grained radioactive dikes and sills described show that the radioactive mineral uraninite

is very likely to occur in or near the upper contact of a sill, especially where there is some flexure in this contact that would tend to impound ascending material, or at the upper termination of a dikelike mass. On the other hand, similar coarse pegmatite dikes that dip steeply and evidently once extended far above the present erosion surface are devoid of radioactive minerals, probably having lost this material due to upward migration.

The fine-grained pegmatite dikes and migmatite zones may contain appreciable amounts of uraninite as well as some molybdenite and pyrite. Even though these bodies dip steeply and evidently once extended well above the present erosion surface, the radioactive material was arrested from upward passage. The radioactive fine-grained pegmatites are largely composed of calcic plagioclase - oligoclase and even andesine - rather than the alkaline feldspars present in the coarse dikes and sills. The alkaline feldspars are the ones to be expected as these fine-grained pegmatites and migmatites generally border consanguine granites and granite gneisses, the end differentiate of which should be alkaline.

These radioactive, fine-grained, oligoclase-rich pegmatites are usually closely associated with schists that are part of the bands of calcareous metasediments sparingly found in most sections of northern Saskatchewan. This relationship may be due to the relative ease of intrusion of the pegmatite-forming material into the schists, and the absorption by this magma of lime from these schists, thus producing oligoclase rather than more alkaline feldspars and would thus tend to crystallize and impede the escape of the U-bearing end liquor. However, some migration and localization of the quartz-rich radioactive end phases of the pegmatite bodies are evident.

There seems every likelihood the pitchblende veins, in at least some areas, are the upward manifestation at a higher, cooler level of pegmatites that at depth had partially or completely lost their U content during consolidation. The pitchblende veins on the W. shore of Black Lake, in northeastern Saskatchewan, are only 20 km. from the uraninite-bearing pegmatites in the Charlebois Lake area and are presumably of the same age.

The presence of Th in a relatively basic rock and schist in the deposit near Upper Peak Lake, 320 km. NW. of Lac La Ronge, is another example of the localization of Th and U in dark basic rocks and minerals that as yet is little understood. --Auth.

1-992. Tremblay, L. P. GEOLOGY AND URANIUM DEPOSITS OF BEAVERLODGE REGION, SASKATCHEWAN: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 491-97, 3 geol. maps, table, Geneva, United Nations, 1958, 13 refs.

The Beaverlodge area is within, and near the western border of, the Canadian shield. It is dissected into ridges trending northeasterly. Relief is generally less than 100 m. (300 ft.).

The oldest rocks, possibly Archean, are called the Tazin group. They were once sediments. Now they are mainly rocks granitized to banded gneisses and granites. Locally they are still quartzite, dolomite, argillite, quartz-biotite schist, garnetiferous gneiss, amphibolite, and chloride-epidote rocks. They are traversed by dikes of coarse red granite. Locally they and the granite dikes are overlain unconformably by conglomerate, arkose, siltstone, and basalt of the Athabasca group which is probably Proterozoic. Gabbro and basalt dikes cut Tazin rocks and at least the lower members of the Athabasca group.

Folds in the Tazin rocks are open, tight, isoclinal, and locally complex. Their axes trend northeasterly with the formations. Most folds plunge gently southwesterly. The Athabasca rocks occur in synclines. Intense zones of brecciation and fracturing are widely distributed in the Tazin rocks and are probably related to zones of early deformation. Later deformation has produced tight fractures in 3 sets of directions. They generally dip southerly. Several major faults such as the Black Bay and St. Louis have been recognized.

U deposits are pegmatitic and hydrothermal. Pegmatitic deposits are in Tazin rocks only and carry some uraninite, monazite, thorite, pyrochlore, and cyrtolite. None has proved economic. Hydrothermal deposits occur in both the Tazin and Athabasca rocks, but almost all production has been from ore bodies in the Tazin. They are of 2 types. The disseminated type, which has provided most of the ore, consists essentially of pitchblende in grains and minute fracture fillings in highly granitized, brecciated, and hematitized rocks. In the vein type, pitchblende occurs in pods, lenses, and true veins. Most deposits are of the vein type but relatively few have proved economic. All ore-zone areas are characterized by: (1) simple mineralogy, mainly pitchblende, calcite, and hematite; (2) dark-red hematitic alteration of the rock; (3) widespread carbonatization, chloritization, and feldspathization.

The following succession of events is suggested for the formation of the deposits:

(1) Broad folding with the development of flexures or drag folds and crenulations on the limbs of the major folds.

(2) A high degree of granitization.

(3) Faulting and formation of wide zones of brecciation or close fracturing possibly accentuated and localized at the crests and troughs of minor folds or flexures.

(4) Circulation of mineralizing solutions along the faults with concentration of pitchblende in the brecciated or fractured zones at fold crests and troughs (the deposits of disseminated type and possibly some of vein type were formed at this stage).

(5) Some hydrothermal alteration, with addition of calcite, hematite, quartz, feldspar.

(6) A later period of fracturing followed by some mineralization (many of the vein deposits were formed at this stage).

The most favorable rocks affecting deposition of pitchblende appear to have been originally siliceous argillite or related mixtures.

The geology and structure of the main mining properties are described specifically. --Auth.

1-993. Butler, A. P., Jr. GEOLOGIC APPRAISAL OF URANIUM RESOURCES OF THE UNITED STATES: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 11-16, Geneva, United Nations, 1958, 26 refs.

The U resources of the United States are in 4 principal geologic environments; terrestrial sedimentary rocks, veins, marine phosphorites and shales, and igneous rocks. These resources include material of ore grade and lower grade. Because dis-

covered deposits constitute only a part of resources, an appraisal of resources requires application of geologic principles to the study of (1) U deposits and districts that are incompletely explored, and (2) geologically favorable areas that may contain undiscovered U.

Most of the better-grade (0.1% U or more) resources in the United States are in terrestrial quartzose and argillaceous sedimentary rocks of Mesozoic and Tertiary age. Resources are preferentially and spottily distributed in favorable facies tens to thousands of square miles in extent in about 10 formations. Because U distribution is stratigraphically selective, resources in some well-studied areas can be estimated from the mineralized fraction of the total outcrop length of a rock unit. Cruder estimates result from general comparison of size of less well-known areas, and distribution of deposits within those areas, with analogous features in better studied areas. Incomplete geologic knowledge about partly prospected areas, and uncertainty as to number and extent of other favorable stratigraphic units that may contain undiscovered U, gives estimates an undetermined margin of error. Ore-grade resources are at least 300×10^6 tons and possibly a few times greater; submarginal resources are comparable in amount.

U resources in veins are mostly in structures cutting brittle competent rocks in or near igneous rocks of Mesozoic and Tertiary age in regions with abundant deposits of other metals but outside areas where those deposits are densely distributed. Many large U deposits and many of the better U-bearing districts are incompletely explored. Resources in them are probably considerably larger than discovered reserves. Moreover, distribution of larger U deposits in widely separated areas having some common geologic features, and general geologic evidence, suggest the presence of undiscovered resources in other geologically similar places in western United States, the Appalachian region, and the Lake Superior region. Consequently, total resources may be large compared to the few million tons that are reasonably assured.

Thin extensive units of marine phosphatic rocks and some black shales of nearly uniform U content are large low-grade resources, actually established as reserves of about 10^{11} tons. These units in the Phosphoria formation, the Bone Valley formation, and the Chattanooga shale contain 50 to 150 ppm., 80 to 120 ppm., and 60 to 80 ppm. U, respectively. In places W. of the Mississippi River, equivalents of the Chattanooga are richer in U and may contain large resources, but other uraniferous shales are thinner or less accessible than the Chattanooga.

Rock adjacent to zoned pegmatite and in unzoned pegmatite containing 500 to 1,000 ppm. U, respectively, constitutes the richest resources of U in igneous rocks in this country. Resources in discovered deposits are a few times 10^6 tons but may be much larger because search for U in other similar geologic settings is incomplete. Vastly larger amounts of resources are in alkali-rich late-stage differentiates emplaced as small batholiths, stocks, and dikes containing 10 to 160 ppm. U.--Auth.

1-994. Keys, W. S., and P. H. Dodd. LITHOFACIES OF CONTINENTAL SEDIMENTARY ROCKS RELATED TO SIGNIFICANT URANIUM DEPOSITS IN THE WESTERN UNITED STATES: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 367-78, map, table, Geneva, United Nations, 1958, 37 refs.

Many U deposits in the western United States are related to lithofacies of continental sedimentary rocks. These lithofacies can be divided into local sedimentary features controlling the position of individual deposits and regional facies distribution patterns to which U districts may be related.

In the United States, major U deposits are in continental sedimentary rocks ranging in age from Triassic to late Tertiary. Approximately 96% of the reserves are in continental sedimentary rocks of the following ages: Triassic (6.6 million tons at 0.36% U_3O_8); Jurassic (51 million tons at 0.26% U_3O_8); and Tertiary (7.8 million tons at 0.23% U_3O_8). Reserves are distributed in a number of districts within which the individual deposits are similar geologically and have a predictable maximum size. These districts show geologic similarities regardless of geographic position or age of the host rock. The recurrent association of U deposits with certain facies of continental sedimentary rocks appears to relate ore genesis and environment of sedimentation.

The host rocks are largely sandstone, with some conglomeratic sandstone, conglomerate, and minor fine-grained clastics. The ore-bearing rocks range from orthoquartzite to feldspathic arenites, with from 3 to 30% feldspar. Carbonaceous plant remains and a pyrobitumen of unknown origin are abundant but not ubiquitous.

Uraninite and coffinite with associated low-valent V compounds impregnate the host rock, commonly as a replacement of the cement. The resulting gray-black sandstones constitute the bulk of United States reserves. These unoxidized ores, thought to be primary, grade into oxidized, yellowish-gray ores. Common minerals in the oxidized zone are tyuyamunite, carnotite, and other uranyl and high-valent V compounds.

Crossbedding, lensing, and rapid texture changes indicate a predominant fluvial environment of host-rock deposition. Well-defined Triassic paleostream channels contain deposits up to 400,000 tons, and anastomosing Jurassic and Tertiary channels localize deposits in excess of one million tons. Ore is commonly near discontinuities in sedimentation and spatially related to lithologic changes.

Belts or districts of U deposits are controlled by regional patterns of lithofacies. Deposits are clustered along pinchouts and in areas with a high rate of facies change. Most major ore deposits are found not in areas of predominant sand or clay deposition but in areas where changing environments produced interfingering fine- and coarse-grained sediments. An understanding of the distribution of sedimentary environments, possibly related to local tectonics, is a prerequisite to logical exploration.

The source of the U and associated metals has not been established. Suggested sources are hypogene solutions, tuffaceous material in and adjacent to the host rocks, and the syngenetic accumulation of uraniferous waters in interior drainage basins. Regardless of source, the deposits are generally considered to be epigenetic. The U apparently moved with a large lateral component in dilute solutions as uranyl complexes. Permeability of the host rocks directed solution flow, and destruction of the carrier-complex ions and reduction of uranyl to insoluble uranous ions caused precipitation.--Auth.

1-995. Russell, R. T. RELATIONSHIP OF URANIUM ORE DEPOSITS TO PETROLEUM- AND

GAS-BEARING STRUCTURES: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 358-66, 3 maps, secs., Geneva, United Nations, 1958, 35 refs.

In the United States, several U ore deposits are located on producing or breached oil and gas structures, or in the immediate vicinity of such structures. Individual deposits associated with these structures contain ore reserves which may exceed one million tons. Data derived from a study of the known deposits should be useful in evaluating the potentiality of other areas where similar structural relations and abnormal radioactivity are known to exist.

U deposits located in producing oil or gas fields include a deposit of more than one million tons of U ore on a single salt dome in Texas, and U deposits in the Poison Basin, Wyoming, which are situated over a producing natural-gas structure, having a potential of 100,000 to 200,000 tons.

Important U mining districts are also located near producing oil fields or near structures which may have contained oil at some time in the past. The Gas Hills district in Wyoming is on the flanks of a breached anticline and within one mi. of natural-gas seeps. Deposits in the Brown's Park formation near Maybell, Colorado, are within 10 mi. of producing oil wells, and natural-gas seeps are known within one mi. of some of the U mines. At Morrison, Colorado, U ore is associated with tar seeps.

On the Colorado Plateau, large ore bodies with total reserves of at least 30 million tons of 0.3% U_3O_8 ore in the Ambrosia Lake district near Grants, New Mexico, contain "asphaltite." Mines in the San Rafael River Desert, Utah, are situated on breached oil structures and produce ore associated with "asphaltite." The uraniferous "asphaltite" ore at Temple Mountain, Utah, has been known for nearly 50 years. At both Circle Cliffs and the Inter-River area in Utah, U ore is associated with asphaltic material on anticlinal structures. Many other deposits are on breached structures that may have contained oil or gas at one time.

In Wyoming, U deposits in Tertiary sandstone and arkose generally lack carbon trash, but are located near oil or gas structures that contain hydrocarbons and natural gases capable of precipitating U.

Also, many U deposits on the Colorado Plateau have insufficient plant remains present to be the fixing agent for U, but petroleum and/or natural gas are proposed as possible extractants. The hydrogen sulfide contained in natural gas or dissolved in oil-field water has been a factor in the formation of some U deposits. Oil-type structural traps must have been effective in localizing both petroleum and U ore in some districts. Although petroleum may contain small amounts of U, it is doubtful if either oil or natural gas are important transporting agents for U. Careful consideration of these various factors will provide a basis upon which to evaluate more effectively many ore-producing areas. --Auth.

1-996. Woodmansee, W. C. RELATIONSHIP BETWEEN SANDSTONE-TYPE URANIUM DEPOSITS AND GROUND WATER IN SOME URANIUM-PRODUCING AREAS: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 351-57, 4 figs. incl. maps, geol. sec., Geneva, United Nations, 1958, 24 refs.

In the western United States, many U deposits in sandstone host rocks are related to present-day water tables. Where no such association now exists, the deposits may have been genetically related to ground-water conditions of the geologic past.

In many areas on the Colorado Plateau, near-surface U ore bodies in sandstone of Mesozoic age are above, and bear little relation to, existing ground-water levels, except for local perched water tables. In the Black Hills of South Dakota and northeastern Wyoming, where host sandstones are of Cretaceous age, the main water table is also at considerable depths below most known ore bodies, but perched water tables coinciding with near-surface deposits are prevalent. In both regions, more recent deep drilling, to horizons where perched or permanent water tables commonly intersect favorable formations, has resulted in the discovery of unoxidized deposits exceeding 100,000 tons. Hundreds of near-surface oxidized deposits are relatively small, measuring up to several thousand tons, because of the greater solubility and redistribution of U under oxidizing conditions. Future additional reserves are postulated in deep, water-table environments.

In the Ambrosia Lake area, northwestern New Mexico, large ore bodies, totaling several million tons in reserves, occur along existing water tables at depths of 500 to 600 ft.

In the intermontane basins of Wyoming and NW. Colorado, U deposits are closely related to ground water. Water tables in Tertiary host sandstones are generally less than 200 ft. below the surface. U deposits typically occur in the zone of the contact between oxidized and unoxidized sandstones, immediately above the water table. Ore bodies are characterized by multiple mineralized horizons. Main considerations in U exploration in these Tertiary basins are the patterns of migration, of ground water, and past and present fluctuations of the water table. Directions of migration define favorable trends of U deposition and redistribution. Water-table fluctuations are believed to influence the stratigraphic range of mineralization. In most of these basins, water tables have probably been lowered since Tertiary or Pleistocene time. Mineralized horizons range chiefly from the surface to depths of the present water table.

In the Gas Hills district of central Wyoming, the most important district in U production and reserves in Tertiary basins, recent geologic work suggests the presence of 3 paleofluviatile drainages or channels which roughly define the main producing areas. These paleochannels trend approximately N.-S. and suggest a source of U and direction of ground-water migration from the S.

The Maybell district, NW. Colorado, is discussed in greater detail as a U district in which sufficient data are available to consider the influence of ground water on U deposition. The geologic and topographic setting of the deposits and structural contouring of the oxidized-unoxidized contact suggest a direction of ground-water migration from E. to W. The oxidized-unoxidized contact is offset in many places by faulting, which appears to have had a pronounced effect on the movement of ground water and ore deposition. Ore bodies are commonly elongated along faults. At least 12 mineralized horizons are known from the surface to depths of 160 ft. --Auth.

1-997. MacKevett, E. M., Jr. GEOLOGY OF THE ROSS-ADAMS URANIUM-THORIUM DEPOSIT, ALASKA: In: International Conference on the Peace-

ful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 502-508, 2 photomicrographs, 2 geol. maps, diag., 2 tables, Geneva, United Nations, 1958, ref.

The Ross-Adams U-Th mine near Rokan Mountain, Prince of Wales Island, Alaska, was found during May 1955 with an airborne geiger counter. Mining commenced during the summer of 1957 subsequent to extensive exploration by diamond drilling. The 1957 production was about 15,000 tons that contained approximately 0.80% U_3O_8.

Granitic rocks of the Coast Range batholith, chiefly granodiorite, quartz monzonite, and quartz diorite, are the most common rocks in the area, but metasedimentary and metavolcanic rocks are exposed locally. The Ross-Adams deposit lies within and near the border of an alkali granite boss or small stock about 3 sq. mi. in areal extent. Excluding dikes, the alkali granite is the youngest crystalline rock in the vicinity, and most U-Th deposits in the district are probably genetically related to it. This rock contains a suite of minor elements that is similar to those in the Ross-Adams deposit and includes abnormal quantities of U, Th, Nb, La, Y, Ce, and other rare earths. Its average U content is approximately 70 ppm.

The Ross-Adams deposit forms a crudely fusiform body that trends N. and has surface exposures over a length of about 180 ft. and an average width of 40 ft. Its depth as disclosed by diamond drilling and mining is approximately 60 ft. Near its southernmost exposures, the ore body is downthrown on the S. by 2 steep, eastward-trending faults. Most of the ore body is flat lying; local steep plunges are drag effects of the faulting. The maximum extent of the ore body S. of the eastward-trending faults has not yet been delineated. The core of the lode contains about 0.80% U_3O_8, and is surrounded by an aureole 5 to 10 ft. thick that has a U_3O_8 content between 0.1 and 0.5%. The ore is slightly richer in Th than in U.

Uranothorianite and uranothorite are the chief ore minerals. Coffinite has been questionably identified, and 5 secondary U minerals occur in minor amounts in near-surface enrivonments. The deposit is red brown - largely an effect of its constituent hematite - and it contrasts sharply in color with the light-gray to white alkali granite host rock.

A combination of 2 processes is postulated for the origin of the deposit. These are a small concentration of uranothorite, a widely scattered minor accessory mineral in the alkali granite, at the site of the deposit, and, subsequent hydrothermal activity that formed numerous uraniferous veinlets throughout the deposit. Probably the eastward-trending faults acted as feeder channels for the hydrothermal solutions as they are locally mineralized besides also having post-ore movement. The veinlets contain uranothorianite along with calcite and hematite, and minor amounts of fluorite, quartz, pyrite, and galena. Commonly they are only a few millimeters thick and trend irregularly. As yet the major controlling factors that caused the concentration of uranothorite and the localization of the U-bearing veinlets are unknown. --Auth.

1-998. Gabelman, J. W., and W.H. Boyer. **RELATION OF URANIUM DEPOSITS TO FEEDER STRUCTURES, ASSOCIATED ALTERATION AND MINERAL ZONES:** In: International Conference on the Peaceful Uses of Atomic Energy, 2d; Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 338-50, 7 maps, Geneva, United Nations, 1958, 18 refs.

Mineral districts in southwestern Colorado commonly contain a central altered area enclosed by irregular zones containing different metal deposits, including U. The central altered area is essentially a high-angle "pipe" which encloses a portion of a major fault zone, or an igneous contact, or is apparently not associated with any major structure. Alteration occurs in all rock types although it is selectively stronger in the metamorphic basement rocks and the intrusives of Tertiary age. Alteration, in paragenetic sequence, is commonly of the argillitic, sericitic, silicic, and pyritic types.

In intensely mineralized districts, veins and replacement bodies occur principally marginal to the central, pervasively altered area, in ground altered only in the wall zones of larger fissures. Deposits within the central altered area are principally replacement disseminations.

Types of metal deposits are generally grouped along preferred structural weaknesses according to distance from the central altered area. Each group defines a zone, partially concentric about a central area.

In some districts specific mineralogic zoning is noticeable. Generally the zones are apparent as precious metal, base metal, and precious metal, from the alteration "pipe" outward.

The central alteration pipe is interpreted as the principal feeder channel for the district and represents the most permeable locality prior to mineralization. Early alteration products are believed to have sealed this permeable area near the surface, forcing later metallizing solutions from the central channel at depth to less permeable available marginal channels. Later solutions rose through successively more distant channels, unless inner channels were reopened or incompletely sealed.

Large, intensely mineralized districts are commonly surrounded by satellite districts which are smaller, less mineralized, and contain fewer zones at greater distances from the main district.

In the western Colorado metallogenic province, U occurs within some central alteration pipes, possibly as a lattice constituent in iron sulfide. Deposits contain less than 100 tons of rock containing 0.03% U_3O_8. U occurs in base-metal zones as pitchblende, commonly associated with Cu. Here deposits are less than 100 tons of 0.1% U_3O_8 material. Commercial U deposits occur on the outer margin of the Au zone, where deposits may be about 50,000 tons of 0.5% U_3O_8 ore.

In the neighboring Colorado Plateau U province, there are many isolated pipelike bodies of weak argillitic, pyritic, and carbonatic alteration, with associated bleaching, and from these the lateral spread of alteration along permeable beds is significant. Impregnations of Cu, V, or U in sandstone occur within altered bodies or in marginal zones, making a geometric pattern similar to the epithermal mineral districts described above.

Many alteration pipes in the southern Colorado Plateau enclose collapsed-breccia or collapsed-plug pipe structures which contain no volcanic material, but which are interpreted as cryptovolcanic structures. Many of these pipes are mineralized by U. Several, having a magnitude order of 30,000 tons of 0.5% U_3O_8 ore per pipe, are known. These pipes are interpreted as possible central feeder structures for districts where the ore is of hydrothermal origin.

Such pipes may not only contain U deposits but may also have supplied laterally migrating solutions from which outlying sandstone impregnations were deposited. --Auth.

1-999. Kerr, Paul F. CRITERIA OF HYDROTHERMAL EMPLACEMENT IN PLATEAU URANIUM STRATA: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 330-34, 2 figs., table, Geneva, United Nations, 1958, 26 refs.

Four hypotheses of U emplacement on the Colorado Plateau now receive support. Three of these appear partially acceptable, but are also subject to serious limitations: (1) the circulatory groundwater theory, (2) the ash-leach theory, and (3) the syngenetic theory. Observations indicate that the fourth hypothesis, the hydrothermal theory, is most likely in the light of recent evidence.

Age data on materials subjected to rigorous mineralogical and geological evaluation are becoming available. Microscopic amounts of galena provide an interfering constituent in most uraninite specimens from the Plateau. In those instances where galena-free uraninite may be found, and coarse isolated galena occurs nearby to establish a Pb correction, microtechniques now available at the Lamont Geological Observatory make possible improved age determinations. These ages, plus data from the literature believed to be acceptable, suggest a range in the periods of U emplacement. In each instance, emplacement appears to have occurred long after the original enclosing sediments were deposited. This implies natural U precipitation from percolating solutions.

Further wall-rock alteration data furnish confirmation of the permeation of Plateau strata by hydrothermal solutions associated with U emplacement. Chrome-mica clay distributed along vertical fractures in sandstone, mica-polymorphs associated with ore introduction, recrystallization of the clay mineral constituents of sedimentary strata, and clay halos associated with ore provide constantly accumulating criteria. More recently discovered alteration sequences in which dolomitization, argillization, and silicification accompany emplacement provide additional evidence.

The minerals of Plateau U deposits yield 11 principal associated metallic elements: Se, Mo, As, Cu, K, V, Co, Cr, Pb, Zn, and S. In the interpretation of the temperatures of emplacement, the minerals which contain Mo, As, Cu, Co, and Cr appear to provide particularly significant data. These 5 elements are found in 52 mineral species scattered through Plateau deposits. In these, distribution, association, occurrence in both hypogene and supergene forms, and general mineral history favor precipitation from solution in the temperature range 100° to 350°C.

Organic materials heavily impregnated with U, now being found in increasing quantities in Plateau ores, indicate U impregnation at temperatures essential to produce cracking of hydrocarbons. Hydrocarbons fragments plucked from sediments and entrapped in sulfide U-bearing vein material yield clusters of spherical gas pockets, an apparent product of natural cracking. This would imply temperatures amounting to more than 275°C. in places.

Significant U mineralization and alteration are associated with breccia pipes and collapse features which vertically pierce horizontal Plateau strata. Similar mineralization and alteration may be found near at hand occupying channels of wide horizontal extent in strata. U-bearing diatremes, associated volcanic vents, and intrusives occur nearby. The igneous features in places furnish significant regional patterns. This is a final link in a chain of geological factors which now appears to indicate an original emplacement of U from post-magmatic hydrothermal solutions.

Acceptance of the data on absolute age, wall-rock alteration, mineral association, organic ore emplacement, and vertical ore-bearing conduits with the time and temperature factors implied renders both the syngenetic and ash-leach theories untenable. It also requires extensive modification of the circulatory ground-water theory to involve an original magmatic source for the U ions. While the weight of evidence supports original U introduction into Plateau strata by hydrothermal activity, subsequent distribution by ground water and superimposed supergene action must be recognized. --Auth.

1-1000. Shawe, Daniel R., N. L. Archbold, and G. C. Simmons. GEOLOGY AND URANIUM-VANADIUM DEPOSITS OF THE SLICK ROCK DISTRICT, SAN MIGUEL AND DOLORES COUNTIES, COLORADO: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 515-22, 8 figs. incl. 2 maps, diags., Geneva, United Nations, 1958, 11 refs.

Sedimentary rocks known in the Slick Rock district in southwestern Colorado range in age from Devonian(?) to Cretaceous, and aggregate about 13,000 ft. in maximum thickness. Important U-V production has come from deposits in the Salt Wash member of the Morrison formation of Late Jurassic age.

The sedimentary rocks are gently folded in the Dolores and Glade anticlines and the Disappointment syncline, and are cut by the Dolores fault zone in the N. part of the district and by the Glade fault zone in the S. part of the district. Principal fracture sets are oriented approximately parallel to the major faults.

Detrital hematite, magnetite, and ilmenite in rocks of the Morrison formation not affected by epigenetic alteration contain appreciable amounts of several of the elements found in the ore deposits. Epigenetic alteration processes have bleached large volumes of rock and largely destroyed these minerals. Such alteration is spatially associated with the Dolores fault zone.

Most of the known ore deposits are in the N. part of the Slick Rock district in a belt called the Dolores ore zone. The zone lies along the Dolores fault zone but is wider than the fault zone. All known deposits are associated with abundant carbonaceous plant material.

U-V deposits in the district are chiefly tabular to lenticular and are roughly parallel to the sedimentary bedding. Some ore bodies, however, are narrow, elongate, and curve sharply across bedding; these bodies have been called "rolls" by the miners. Mineral zoning is evident in some roll bodies; carbonates, goethite (altered from pyrite), selenides, and sulfides are commonly found in concentric layers at the concave edge of rolls. This zoning, and the relationship of roll ore bodies to sedimentary structures and lithology, suggest that ore was deposited at an interface between 2 solutions, possibly cool connate water and a warmer ore solution.

On a district scale, Cu and Pb are distinctly

most abundant in the ore deposits within and immediately adjacent to the Dolores fault zone, and less abundant in deposits toward the edge of the zone.

U-V deposits in the district occur only in sandstone that is considered to be epigenetically altered, and the most extensive epigenetic changes have occurred close to ore bodies.

It is concluded that ground water, heated and set into circulation near the end of Cretaceous time by igneous intrusions in the La Sal and other centers on the Colorado Plateau, picked up elements from sedimentary rocks where they had been faulted and fractured, and deposited the elements at solution interfaces where accumulations of carbonaceous material provided favorable chemical conditions for precipitation. --Auth.

1-1001. Hart, O. M. URANIUM DEPOSITS IN THE PRYOR-BIG HORN MOUNTAINS, CARBON COUNTY, MONTANA, AND BIG HORN COUNTY, WYOMING: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 523-26, 2 maps, Geneva, United Nations, 1958, 2 refs.

U deposits in the Pryor-Big Horn Mountains of Carbon County, Montana, and Big Horn County, Wyoming, occur in the Madison limestone of Mississippian age. This district forms part of the northern rim of the Big Horn basin in northern Wyoming and S.-central Montana. Structurally, the area is a compound uplift consisting of numerous asymmetric anticlines and monoclines, several of which are faulted. These structures were formed during the Laramide orogeny by recurrent movement along zones of weakness within the Precambrian complex.

The U deposits are located in karst topography in caves, sheet breccias, and silt and clay fillings of the karst caverns. The fill material is insoluble residue from solutions of the limestone and silt in beds overlying the Madison limestone. The ore mineral is tyuyamunite and metatyuyamunite, closely associated with crystalline calcite. These minerals were deposited together in ponded waters within coverns, in silt and clay fillings, along walls of open solution joints and water courses, and through parts of the prominent solution breccia forming the floor of cavern development.

Most deposits contain from a few tons to 500 tons, although a few range up to 8,000 tons. The ore bodies conform to the size and shape of the cavern or solutional form in which they occur. The tenor of the ore is high, usually exceeding 0.50% U_3O_8, with some ores assaying as high as 4.0% U_3O_8. The V_2O_5 content is 20 to 40% higher than U. Associated minerals in ores are calcite, limonite, hematite, barite, various clay minerals, and locally gypsum, fluorite, and celestite.

The exploration problem in this district consists of locating the courses or channels of the mineralizing solutions through the complex "plumbing system" of the karst topography and finding the filled or plugged caves containing mineral concentrations.

Ore deposition and solutional modifications within the Madison limestone are believed to be directly related to the erosional events of reexcavation of the Big Horn basin, and were probably contemporaneous processes. U was apparently derived from fluvial erosion of volcanic-rich alluvial sediments, enriching ground water, which subsequently lost its dissolved constituents in the karstlike environment in the limestone during the early stages of the presently active degradation cycle of the region. An alternate origin of the U may have been solutions which originated at depth and ascended along the major faults, finally mingling with ground water and percolating through near-surface zones.

A contrast may be drawn between the U deposits in limestone of the Pryor-Big Horn Mountains and those in the Todilto limestone of Jurassic age in the Grants district, New Mexico. In the latter area, the emplacement of primary uraninite-pyrite ore bodies has been controlled by tectonic folds, tension fractures, and pressure recrystallization. Ore solutions were probably introduced into folds laterally, through permeable zones created by tension fractures. The grade of U ore in the limestone of the Grants district is generally proportional to the intensity of folding. Shallow folds contain the larger ore bodies, up to 100,000 tons with grade on the order of 0.2% U_3O_8, whereas sharper folds contain somewhat higher-grade ore. --Auth.

1-1002. Hilpert, L. S., and R. H. Moench. URANIUM DEPOSITS OF THE SOUTHERN PART OF THE SAN JUAN BASIN, NEW MEXICO: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 527-38, 15 figs. incl. geol. maps, secs., Geneva, United Nations, 1958, 6 refs.

U ore reserves of the southern part of the San Juan basin total 52 million tons, averaging 0.26% U_3O_8. These reserves constitute 80% of the total in the Colorado Plateau and 70% of the United States total. Nearly all of these reserves are in the southern part of the San Juan basin, McKinley and Valencia counties. This area probably also contains many millions of tons of potential reserves.

The U deposits are in a sequence of sedimentary rocks that range in age from Permian to Cretaceous. The most important host rocks are sandstone units in the Morrison formation. Less important as a host is the Todilto limestone and, locally, the underlying Entrada sandstone, both of Jurassic age. A few small deposits are in the Dakota sandstone of Cretaceous age.

The host rocks crop out along the southern margin of the San Juan basin and dip gently northward. The U mining district crudely parallels the outcrops, and is bounded on the S. by the Zuni and Lucero uplifts, and on the E. by the N.-trending Rio Grande trough.

The U deposits in the Morrison formation range in size from those containing a few tons to those containing several million tons of ore. Most comprise one or more nearly horizontal layers and are crudely elliptical to fingerlike in plan. A unique small high-grade deposit is in a vertical sandstone pipe.

Deposits in the Todilto limestone, a few hundred to about 100,000 tons in size, are in the flanks of crests of small folds in the limestone, and are commonly fingerlike. Small semitabular deposits containing at most a few hundred tons occur in the Entrada sandstone. Deposits as much as a thousand tons in size are found in the lenses at the base of the Dakota sandstone.

Much of the ore is composed of disseminated uraniferous carbonaceous material. Coffinite probably is the dominant primary U mineral in the

sandstone ores, and uraninite in the limestone ores. Above the water table much of the U is in a high valence state. Pyrite and marcasite are locally abundant in unoxidized ores. The ratio of U to V for all ores combined is 2:1.

The deposits probably were emplaced during early Tertiary time possibly during or after regional northward tilting, but before the sinking of the Rio Grande trough, before formation of the principal fracture systems, and before the igneous activity in Miocene and Quaternary times. --Auth.

1-1003. Yrigoyen, Marcelo R. THE MALARGÜE URANIUM-BEARING DISTRICT, IN THE SOUTH OF THE PROVINCE OF MENDOZA: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 539-48, 2 maps, 2 cross-secs., 3 tables, Geneva, United Nations, 1958, 5 refs.

A vast uraniferous belt begins in the area of Malargüe [Argentina], and extends to the S. over a distance of some 350 km. Its northern end contains a region characterized by the existence of several deposits of interest, among which are the Huemul and Agua Botada measures, which are currently being worked.

A series of radioactive occurrences are to be found in the lower half of the middle Cretaceous (Diamantian) around the closures of the anticlinal structures of Malargüe and Pampa Amarilla. The rest of the local sedimentary mass also is to be found inside the zone, from the upper Triassic to the Quaternary, with a covering, in the latter, of ignimbritic tuffs showing high radioactivity. The series of igneous rocks is represented by granites, porphyries, Triassic porphyrites, and acid and basic volcanites of Cenozoic age.

The uraniferous deposits correspond to concentrations of carnotite, uranophane, and tyuyamunite which dominate among the secondary minerals, and pitchblende among the unoxidized ones. They are accompanied by copper sulfides and carbonates and Fe minerals. The deposition corresponds to hydrothermal solutions which have precipitated the uraniferous varieties within the sandstone sediments, which contain much bituminous material (asphalt), of the middle Cretaceous.

Tectonically, the area is of a relatively smooth type, and there are folds and faults, in part contemporaneous with the intrusion of andesites in the forms of dikes, lodes, and stocks.

Structurally speaking, the deposits are found where they are supposed to be, since they are confined to specific sectors by considerations of porosity and permeability. --Auth. (transl.).

1-1004. Angelelli, Victorio, and Armando Ortega. A CONTRIBUTION TO THE KNOWLEDGE OF THE URANIFEROUS LUTITES OF THE PROVINCE OF SAN JUAN (ARGENTINA): In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 549-54, map, 2 secs., 2 tables, Geneva, United Nations, 1958, 5 refs.

Outcrops of U-bearing lutites are to be found in the western fold of the San Juan foothills, at the level of the villages of Calingasta and Rodeo, as well as in the eastern sector of this structural unit to the N. of the city of Jachal.

These sediments, which are a part of the early Paleozoic formations which constitute the foothills, make up a large area of such outcrops. Their thickness varies from some tens to some hundreds of meters, according to location. The dominant orientation is N.-S., with a variable dip. In some areas, they are folded and very much broken (Calingasta). They are finely stratified, pitch black to grayish black in color when altered. They consist, in the main, of clayey material, organic matter, and quartz, with some carbonates, pyrite, hematite, and sericite. Their composition is not homogeneous, as shown by microscopic and chemical analyses. These sediments are of marine origin and seem to belong to the Ordovician. In some parts they contain fossils. Their U_3O_8 content, as determined fluorometrically, varies between 20 and 30 grams per ton.

By meteoric alteration, these lutites, in the Calingasta area, gave origin to some sulfates (epsomite, alunogen, and pickeringite), which are being worked. --Auth. (transl.).

1-1005. Mårtensson, Carl, and Eric Welin. URANIUM MINERALIZATION IN IRON ORES OF CENTRAL SWEDEN: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958, Proceedings, v. 2, Survey of Raw Material Resources, p. 560-63, photomicrograph, map, table, Geneva, United Nations, 1958, 2 refs.

The Archean bedrock of central Sweden consists of highly metamorphosed leptites, greenstones, and sedimentary rocks penetrated by various granites and pegmatites. Parts of this area are rich in different ores among which the Fe ores are the most important. Skarn-type ores are common, and in some of them U minerals have been found.

The investigation of this U mineralization is still going on. Until now, it has been shown that U, in form of primary and secondary minerals, is concentrated in tectonized zones of the skarn rocks. The Fe ore, usually magnetite, and penetrating pegmatites are not U bearing. --Auth.

1-1006. Lenoble, A., and A. M. Gangloff. THE PRESENT STATE OF KNOWLEDGE OF THORIUM AND URANIUM DEPOSITS IN FRANCE AND THE FRENCH UNION: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 569-77, map, Geneva, United Nations, 1958, 21 refs.

The major part of the reserves insuring present and future production for the next few years is to be found in the Hercynian crystalline zones of the Forez, the Limousin, and Vendée. They are the Bois-Noirs, Brugeaud, Fanay-les-Sagnes, Margnac, la Chapelle Largeau, l'Ecarpière, and la Commanderie fields. Their general characteristics are given, together with the scale of their proved extension, determined either by mining works or by drilling.

In each of these districts, moreover, numerous occurrences have been located, some of which are now under proving by mining works; prospecting is carried on, using more efficient methods, and is continuing to bring in more occurrences.

Apart from these 3 massifs, other Hercynian zones, either in the Massif Central or in Brittany, are liable to contribute greatly to U supplies in the near future. During the last few years, various private firms have undertaken mining surveys. The Commissariat à l'Energie Atomique (C. E. A.) has

completed the survey of the uraniferous-shale field in the Vosges.

These ore bodies are now expected to yield a definite output. Besides, preliminary prospecting for new occurrences in other districts and, in some cases, in other geological conditions, have been carried on, either by the C. E. A. or by private companies. New results have thus been obtained, particularly in the Permian sandstone of southern France. The successful results arrived at and the character of the ore bodies encourage the use of more accurate detecting methods than ever.

For the whole of the Overseas Territories, the only production center so far is in Madagascar (uranothorianite fields). But, in Gabon, a newly-discovered ore body is now under development and will contribute to output in the next few years. Its essential characteristics are indicated in this note.

Prospecting efforts have considerably increased in Overseas Territories; vast projects have been continued or launched in Madagascar, Africa, and French Guiana. Prospecting in these vast and often inhospitable regions implies the development and adjustment of reliable methods.

As far as Th is concerned, the only fields now under exploitation are those of Madagascar: the uranothorianite deposits and monazite beaches. --Auth. (transl.).

1-1007. Sarcia, J. A., H. Carrat, A. Poughon, and H. Sanselme. GEOLOGY OF URANIUM VEIN DEPOSITS OF FRANCE: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 592-611, 20 figs. incl. maps, sec., Geneva, United Nations, 1958, 21 refs.

This type of deposit still constitutes the bulk of domestic U reserves. They occur in all Hercynian areas, but the most important and the best known are located in the Massif Central and in Brittany. This report is only concerned with the deposits discovered and developed by the French Commissariat à l'Energie Atomique, since 1946, i. e., those of Forez in the Massif Central, those of Morvan and Limousin, and those of the Massif de Vendée.

All these mineralized districts occur in granite bodies, more or less enriched with muscovite, in rough conformity with Hercynian folding: NW.- SE. in Vendée and Limousin, NE.-SW. in Forez and Morvan. All the veins are located inside granite, except in Vendée where some of them also occur in metamorphic country rocks. Their directions vary according to the different districts. All of them are characterized by the frequency of their occurrence along mafic lodes or differentiations and the poverty of mineral associations-mainly pitchblende with few accessory sulfides.

Gangues are sometimes lacking. When they appear, they belong to siliceous-, fluorite-, or smoky quartz-bearing types. The last one may be superposed to the others as a late hydrothermal [migration].

U deposits of the mining district of Forez belong to 3 different types: 1) the "Bois-Noirs" type, with tiny pitchblende in a siliceous gangue, located in a biotite-granite, evolving to a granite porphyry; 2) the "Ambert" type, with pitchblende agglomerated in rich lenses, irregularly scattered in an irregular fissure pattern in anatexites; and 3) the "Lachaux" type, where U occurs as parsonite, in thick smoky-quartz veins.

In Morvan, pitchblende mineralization occurs: 1) in shear zones of a biotite granite, in thick veins of fluorite with chalcedony - this is the "Bauzot" type; 2) in shear zones of a biotite and muscovite granite. The mineralization is located in hematized brecciated mylonites, often with more or less carbonates - this is the "Saint-Symphorien de Marmagne" type; 3) in the mining district of La Crouzille (Limousin), U concentrations occur in a biotite-muscovite granite; they are characterized by a very small quantity or lack of gangue.

In Vendée, all the ore bodies seem to be related to the same biotite-muscovite granitic strip as in N. Limousin. It is included in the granite country rock. Pitchblende occurs: 1) in northern Vendée, in thick siliceous veins located in granitic rocks, near the contact with metamorphics; it is mainly associated with fluorite in the Ecarpière deposit, and only chalcedony at La Chapelle. The veins are characterized by their great horizontal extension; 2) in southern Vendée, in a complex fissure pattern, both in granite and metamorphics. Pitchblende is massive and gangue less - "Les Herbiers" area.--Auth. (transl.).

1-1008. Sarcia, J. A. THE URANIFEROUS PROVINCE OF NORTHERN LIMOUSIN AND ITS THREE PRINCIPAL DEPOSITS: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 578-91, 9 figs. incl. maps, sec., table, Geneva, United Nations, 1958, 4 refs.

The 3 mining districts described are perfectly representative of the uraniferous deposits of northern Limousin [France], and belong to 3 types differing in both structural and economic points of view.

The deposit at Les Sagnes is above all a vein deposit with grade of ore varying from 0.7 parts per thousand to several percent, depending on the mineralized body, but with an average grade for the deposit as a whole ranging from 1.6 to 2 parts per thousand.

Margnac district has veins with grade of the order of 2 to 3 parts per thousand which periodically expand into lentils with considerable tonnage and grade of several percent.

In Les Brugeauds deposits, veins are associated with masses of ore, the latter being predominant, and the grades vary from a few parts per ten thousand to a few percent, the average grade of the workable masses ranging from 1 to 1.3 parts per thousand.

It is evident that the occurrence within a small area (the mining district is 320 km.^{2}) of 3 types of deposits with grades of ore to some extent complementing one another is of great interest to the mining industry both from the technical and the economic points of view. --From auth. concl.

1-1009. Mabile, J. DEVELOPMENT OF THE URANIUM MINING INDUSTRY IN FRANCE AND IN THE FRENCH UNION: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 40-42, table, Geneva, United Nations, 1958.

The U prospecting and mining policy in France and in the Union Française has proved a definite success. Since 1946, when only a few mineralogic occurrences were known, which the experts considered as being without any economic significance, the number of discoveries increased and led to an already important

output in 1958; this production makes France one of the leading world producers and makes its future look even more promising.

The geological factors in these discoveries, as well as the technique of the prospecting methods, will be discussed elsewhere.

It seems worthwhile to give an historical account and then draw a lesson from it. At the first stage, the French Government had to find U at all costs to make possible the atomic development which had been decided upon at the end of World War II. This venture ended rapidly with the first discoveries of commercial deposits.

At the second stage, it was possible to set up a limited program for mining development; moreover, the efforts we devoted together with a constant open-mindedness on the promises of these deposits, brought us to the idea that these deposits belonged possibly to a uraniferous province of worldwide significance.

Then the years 1954-1955 marked a conclusive step forward and the beginning of the third stage which the C. E. A. [French Atomic Energy Commission] mines actually completed, while private companies played their part actively under the Government's incentive.

It is of course unquestionably fortunate that our country should have been in a U-bearing geological province. Moreover, this remarkably rapid expansion is explained by the fact that all prospecting and even development operations were centralized and entrusted to one single department. It is unlikely that a dispersion of efforts should have brought about the same results, if only at the preliminary stage, the risks of which, in any case, could not have been taken by private industries.

In the technical field, we must point out that we owe our success to the open-mindedness attained by our geological staff in the course of their work. Our own experience, both in the Overseas Territories and at home, confirmed the view arrived at all over the world that it is impossible to foresee the type of deposit of a new province.

The necessity of special legislation has often been the cause of some concern. It is noteworthy that in France, where no such legislation has been decreed for U, which is treated as any other metal, the expansion of prospecting can be compared to that of the most dynamic of new countries.

On the world level, our experience, together with that of neighboring countries, fairly proves the existence, in western Europe, of a rich U province. Furthermore, hopes have been raised overseas, and we can be sure that this first example of a discovery we have just made will be followed. Therefore, the world is not faced with a U shortage. On the contrary, this relatively abundant supply may give rise to some economic problems in the next 10 years or so. The diversity of our deposits, the dispersion of the grades throughout one ore body or from one ore body to another, will enable the adjustment of the U industry to any change that may arise in the economic situation. --Auth. (transl.).

1-1010. Alía, M., J. L. Rebollo, J. A. Fernández Polo, C. Bonet, and F. de Pedro. RADIOACTIVE MINERALIZATIONS IN THE CENTRAL REGIONS OF SPAIN: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 622-28, 5 geol. maps, Geneva, United Nations, 1958, 3 refs.

The uraniferous mineralizations encountered in the ancient terranes of the Cordillera Central appear to be related to the initial uraniferous enrichment, which must have occurred in the more acid and evolved forms of the Hercynian granitizations. Those found in certain rock dikes, such as aplites, should be regarded as being the same age and must have also been produced by the concentration of U during the process of differentiation. The mineralizations related to quartz-vein structures might in some cases correspond to ancient hydrothermal forms, but in many instances show a clear relation to Alpine structures. This fact leads us to believe that the movements of this age had an influence on the formation or redistribution of these concentrations. In some cases, the mineralizations were mainly produced by the circulation of water with U through Alpine gneiss fractures. The U must have been extracted from the surrounding rocks, and the water could have been thermal, in view of its deep circulation. The process would, consequently, be different from hydrothermal action of magmatic origin and independent of Hercynian magmatic action. The fracturing caused by Alpine movements could also have produced concentrations and secondary redistributions in the older deposits, as assumed in the case of the aplites.

As far as the uraniferous mineralizations discovered up to now in the Miocene of the Tajo rift valley are concerned, we have inferred, as the likeliest hypothesis, that this U must have originated from lixiviation of the ancient materials of the Cordillera Central. The depositing must have been brought about by the presence of reducing media, as in the case of Paracuellos de Jarama, or by changes in pH and chemical reactions, as we have assumed in the case of Borox. The subsequent circulation of deep waters could have had a great influence on the displacement of the mineralizations and on their redepositing in favorable structures or lithologic levels. --From auth. concl.

1-1011. Garcia de Figuerola, L. C., and E. Ramirez. RADIOACTIVITY OF THE BATHOLITH AT PEDROSO, SEVILLE PROVINCE, SPAIN: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 629-31, Geneva, United Nations, 1958.

The Pedroso batholith is found in the northwestern corner of the Province of Seville, and it is made up of granitic rocks of various types, among which the coarse-grained biotitic varieties are predominant. In most instances, they give very high radioactivity readings. This batholith is surrounded by metamorphic rocks, principally micaceous, with Paleozoic limestones (Cambrian and Silurian) which also give a high radioactive background in many instances.

A tectonic and stratigraphic study of the adjacent areas indicates the existence of very marked movements which date back to an earlier period than the Permian-Triassic epoch, and others, of a later date, which reactivated the old breaks. These did not affect the upper Tertiary. Similarly, they did not give rise to the formation of structures favorable to U mineralization.

Fairly extensive Fe deposits are to be found at the point of contact between the batholith and the country rocks, but these do not contain any appreciable amounts of radioactive elements which, naturally, are present in smaller proportions than in the granites and metamorphic rocks. We feel that these deposits are a "basic front" and further be-

lieve, therefore, that the U was mobilized, neither at the same time as the femic components, during the formation of the granite, nor at a subsequent epoch through a rheomorphic process. --Auth. (transl.).

1-1012. Santana Perez, D. URANIUM MINING IN SPAIN, CURRENT STATUS AND PROSPECTS: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 43-49, geol. map, Geneva, United Nations, 1958.

The results obtained in the mining research work conducted in the most interesting radioactive areas of Spain are reviewed in this paper. A brief mention is made of the work already carried out and of that which is now still under way, as well as of future plans, in the areas of research and actual working of the mines. A study is presented of the known veins and mineral associations, as well as an analysis of the economic potentialities of each of these occurrences.

The prospects of radioactive-substance mining in Spain are reviewed in the light of the results achieved. --Auth. (transl.).

1-1013. Pires Lobato, C., and C. Neves Ferrão. THE OCCURRENCE OF URANIUM ORES IN FORMATIONS OF PRE-ORDOVICIAN SCHISTS, PINHEL, PORTUGAL: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 651-57, 6 figs. incl. maps, Geneva, United Nations, 1958, 9 refs.

The occurrence of U ores in concentrations of economical interest in the pre-Ordovician schists was noted at Senhora das Fontes, in the region of Pinhel.

The occurrence is situated in a zone of graphitic brown-grayish schists which are enclosed in a formation of gneiss with tourmaline near the contact of the latter with the Hercynian granite, which constitutes the Beiras Massif. The uraniferous mineralization consists of autunite down to the depth which has been reached by the exploration works. The predominant joint systems in the schists are oriented in the direction N. 10° W. and N. 80° W., and have vertical or sub-vertical dip. The planes of schistosity strike along the same direction of the schist zone.

The radiometric study and the sampling taken at the depth of about 10 m. suggest the continuity of the structure and the persistence of the mineralization associated with it.

The structural type and the distribution of the mineralization in the joints and the brecciated zone of the schists suggest that the deposition of U ore is not syngenetic, but, rather, that it is attributed to the circulation of mineralized solutions through the breakage produced along the hydrothermal veins, in a posterior reopening connected to the last movements of the Alpine orogeny.

The content obtained in the sampling reveals the existence of an enlarged ore deposit following the directions of the schistosity, with an extension of 140 m. and with the average content of 0.27% U_3O_8.

Nine other occurrences were afterwards located in formations of pre-Ordovician and Silurian schists. These have not yet been studied in detail, but promise to have economic interest.

These occurrences are usually situated near the contacts of the migmatitic schists and gneiss with the Hercynian granites. --Auth. (transl.).

1-1014. Pires Lobato, C. TECTONIC SYNTHESIS OF PORTUGUESE URANIFEROUS DISTRICTS: DISTRIBUTION OF MINERALIZATION IN THE BEIRAS REGION: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 632-50, 12 maps, Geneva, United Nations, 1958, 17 refs.

The Portuguese U deposits settled on structures resulting from the Hercynian and Alpine orogenies of the Iberian Peninsula, making up late types, probably of the middle Alpine phase of the latter movements, and of an age which is upper Eocene and Oligocene.

The geographical distribution of the mineralized zones is related to the marginal tectonics of the central chain, suggesting that the areas of most intense mineralization are placed in Districts B and C, with a progressive decrease to the NE., on each side of the Estrela mountains. The possibility of mineralization of the veins belonging to District A, with fluids already removed from its most intense center, accounts for the ease of fracturing along the vast network of basic rocks which intersect the marginal masses of the northern ridge of the Serra de Estrela.

The white-quartz veins, with very abundant limonite in their breccia-formed walls, represent the transition of the black quartzites toward the jaspoids. They offer no economic interest in depth, because of their rapid tailing off.

The statistical elements bearing on the distribution of the mineralized pockets revealed the existence of equilibrium in weight units of U_3O_8 per surface unit in the tension fractures of a regional and local type with greater values for the last named.

In the European uraniferous province, Portugal has been deeply affected by the Hercynian and Alpine orogenies, the latter being more recent and, therefore, more in evidence. Portuguese U is found sometimes in hydrothermal veins and structures which have been reopened, and sometimes close to the denuded granitic batholiths, highly brecciated, in which epithermal veins of the Meso-Alpine type have been formed and show the greatest concentrations of ores.

The axis of mineralization of U in Portugal follows the NE.-SW. alignment, intercepted along the Hercynian massif blocks, presenting paragenetic and structural differences related to the geological and geochemical behavior of the same masses.

It seems to us that the recent discoveries of uraniferous deposits on the schists of the Lower Ordovician schists-graywacke complex, related to the Hercynian structures which faulted during the subsequent movements, are not an exception to the general ideas which we have exposed herein.

Regarding the Portuguese granitic mass, we are now investigating possible relationships between the zones most attached to metamorphism and the localization of radioactive indices. --Auth. concl.

1-1015. Cavaca, R. SOME RESULTS OF URANIUM PROSPECTING IN PORTUGAL: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 50-53, 3 maps, table, Geneva, United Nations, 1958, ref.

In a note presented to the First International Conference on the Peaceful Uses of Atomic Energy, the author made a brief summary of what had been learned

until then about the metallogeny of U in Portugal, in European territory as well as in the overseas provinces of Angola and Mozambique, and he explained the plan and working methods selected for the systematic prospection to be carried out in Portugal.

The present paper refers to works carried out from June 1955 to Dec. 1957, with special reference to the different metallogenic types of the U deposits that have been studied up to the present moment.

The study has been made of about 200 mineralized occurrences which permitted the selection of 80 deposits of outstanding interest and permitting the best economical expectations.

In accordance with the structural characteristics and with the gangue nature, the following metallogenic types can now already be mentioned:

1) Quartz veins with abundant red jasper, chalcedony, and primary and secondary U minerals.

2) Quartz veins with jasper and chalcedony in small amounts and U mineralization similar to that referred to in 1).

3) Barren quartz veins, with limonitic concentrations well developed in the wall-rock brecciated zones with secondary U mineralization.

4) Saccharoidal and smoky quartz veins, showing an increase in areas and crystallization in geodes, with primary and secondary U minerals.

5) Stockworks in granite and migmatitic formations, with primary and secondary U mineralization.

6) Doleritic dikes with autunite impregnations in the fissures.

7) Faults, brecciated and migmatitic structures, with secondary U mineralization.

8) Impregnation of secondary U minerals, especially autunite, in granites.

9) Impregnation of secondary U minerals, mainly autunite, in gneiss.

10) Autunite impregnations in the graphitic and argillic schists.

11) Mixed types of those mentioned above.

Some of these deposits have already been the object of a reconnaissance carried out through drilling and mining works, which permit an increase of economic potential to be granted, especially in the case of those mentioned in numbers 1, 2, 4, 5, and 10 of the above list. --Auth. (transl.).

1-1016. Ippolito, Felice. THE URANIUM-BEARING FORMATIONS OF THE SEDIMENTS OF THE LATE ALPINE PALEOZOIC: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 612-21, map, diag., Geneva, United Nations, 1958, 3 refs.

The most important and well-known U deposits of the Permo-Triassic series of the Western Alps, Italy, are located at Rio Freddo (Peveragno, Piedmont) and at Preit (Val Maira, Piedmont). The U minerals are concentrated in very thin beds alternating with micaceous chloritic layers and paralleling the schistosity. The deposits are limited to the upper metamorphic complex, and almost always lie very close to the marine quartzite. A second type of U concentration occurs in a rather coarse-grained rock particularly rich in cataclastic fragments. These are discontinuous laterally and vertically. The difference between the 2 types is thought to be due to the peculiarities of Permo-Triassic marine transgressions on an already peneplained coast. Primary pitchblende, resulting from the metamorphism of a part of the original organic U compounds, is a dominant mineral in these deposits, but its occurrence is within limited areas. Other evidence points to the contemporaneity of the precipitation of U and sedimentation, as well as some U migration.

Several U concentrations have been discovered in a survey of the Hercynian Val Gardena arenites in the area between the Bergamaschian and Carnian Alps. The U deposit of Val Daone is enclosed by coarse-grained sandstones near the granodiorite massif of Adamello. A third of the same type of deposit occurs at Val Rendena. The host sandstones of these deposits are characterized by a greenish-gray color, typical of sediments which have undergone chemical alteration. U appears to be the result of concentration during diagenesis or, more probably, during the alpine orogeny. Analyses for V, P, Cu, Pb, and As indicate a sedimentary origin for the deposits.

U also occurs in a medium-grained rhyolitic ignimbrite of possible Permian age near Varese in the Central Alps. A sedimentary genesis is proposed for the U, which is disseminated in the rock cement of the tuffaceous facies. --G. E. Denegar.

1-1017. Barabás, A., and Jean Kiss. THE GENESIS AND SEDIMENTARY PETROGRAPHIC CHARACTER OF THE ENRICHMENT OF URANIUM ORE IN MECSEK MOUNTAIN: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 388-95, 7 figs. incl. photomicrographs, graphs, table, Geneva, United Nations, 10 refs.

The genetic conditions of the uraniferous concentration of Mecsek mountain [Hungary; 46°06'N. 18°13'E.] can be related to the following factors:

1) The uraniferous deposit is of magmatic origin, being the product of denudation of a hydrothermal deposit of U ore (Bi-Co-Ni formation).

2) The U was transported in mechanical components, in the dissolved state and linked to argillaceous sediments.

3) The present metalliferous deposit was formed in a paludous basin.

4) Organic matter and sulfidic minerals provided only the reducing medium; they played no part in the fixation of the U.

5) The deposits are lenticular, with local accumulation.

6) In contrast to organic matter, we attribute great importance to argillaceous minerals, especially Cr-mica, with respect to fixation of the U ore.

7) The subsequent oxidation of the deposits is visible only in parts nearest the surface, along fault lines, but, in general, is not significant. --Auth. concl.

1-1018. Jantsky, B., Jean Kiss, S. Lengyel, D. Szy, and K. Viragh. A CHARACTERISTIC CASE OF URANIUM MIGRATION OBSERVED IN THE FOOTHILLS ALONG THE SHORE OF LAKE BALATON: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 564-68, 4 illus., sec., Geneva, United Nations, 1958, 9 refs.

U was discovered in bituminous marl in association with fluorite and fluorapatite in parallel fracture zones along the NW. shore of Lake Balaton, Hungary (46°50'N. 17°50'E.), by means of aerial and carborne radiometric surveys. The bituminous marl occurs,

for the most part, as tectonic breccia-zone cement in the Megyehegy dolomite, conchitic and siliceous limestone. It also occurs as breccia rubble and as intercalations.

The bituminous material is combined with a carbonated fluorapatite of high P_2O_5 content. The tectonic breccia is permeated by fluorite developed in veins and druses. Certain veins of calcite alternate with threads of fluorite. Hollow pockets are filled with powdered limonite, perhaps originally siderite or ankerite clusters leached by surface waters. U, however, exists only in the bituminous phosphoritic material.

The bituminous material is thought to have migrated into the fracture zones by means of hydrothermal activity. The fluorite, bitumen, phosphorite, and U occur only at the point where the fractured and crushed rock zone runs into the complex situated above the Megyehegy dolomite. The fluorite probably originated from the fluorapatite; the U from the primary bituminous sediment. The hydrothermal activity which caused the migration of the bituminous phosphoritic material and the introduction of the other mineralization was probably a late effect of the Pliocene basaltic volcanism which occurred in the vicinity of this region and which produced similar low-temperature alterations elsewhere. -- G. E. Denegar.

1-1019. Gritsaenko, G. S., L. N. Belova, R. V. Getseva, and K. T. Savelyeva. MINERALOGICAL TYPES OF OXIDATION ZONES OF HYDROTHERMAL URANIUM AND SULPHIDE-URANIUM ORES OF THE USSR: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, p. 466-74, 4 figs., Geneva, United Nations, 1958, 10 refs.

The oxidation zones of hydrothermal U and sulfide-U deposits in the U. S. S. R. belong to the fracture type. This determines the possibility of occurrence of primary and U black powder ores in the densest (least fractured) blocks of the upper parts of ore bodies, and the presence of alluvial sections at a depth much below the ground-water level. Morphologically, the oxidation zones are complex tongue-shaped bodies, generally tending to grow thinner towards the bottom, having squeezes, swells, branches and underground pockets, developing in dependence on both the fracturing and the composition of the oxidizing material.

The mineral paragenesis characteristic of the oxidation zones of hydrothermal U deposits depends on the primary composition of the ores and the country rocks. In other words, other conditions being equal, they are determined by the medium in which they are developed. The most important factors in this connection are the degree of pyritization of the ore bodies and country rocks, ratio of iron disulfides to neutralizers in the ore bodies and country rocks, and presence or absence of U fixers and adsorbents (arsenate, phosphate, and silicate ions, iron and manganese hydroxides).

Over 80 mineral species and varieties have been found in the oxidation zones of the deposits in question, almost half of them being proper U and U-bearing minerals including several new and a number of rare ones.

The following types of oxidation zones can be established with respect to secondary U mineralization: 1) hydroxide-silicate, 2) silicate proper, 3) silicate-mica, 4) mica proper, 5) mica-limonite. The first 2 types above develop U proper ore bodies containing very small quantities of sulfides or not containing them at all.

Silicate-mica oxidation zones form under conditions of either low or medium sulfide content in the presence of a large amount of neutralizers. Mica and mica-limonite oxidation zones are characteristic of typical sulfide U deposits, a whole range of transitions from pure-mica to pure-limonite oxidation zones forming, depending on the sulfide content.

The presence of U in oxidation zones which do not contain individual U minerals or contain them in small quantities can be characterized by adsorbent minerals, primarily by iron hydroxides. The determination of a relation between the U content in limonites and the type of the mineralization in the zone verified for a number of deposits, permits us to raise the importance of mineralogical criteria in evaluation of deposits by their outcrops, as well as to show the role of adsorbent minerals as U prospecting guides.

Secondary zonality in the oxidation zones of hydrothermal U deposits is not constant but depends on the actual conditions under which the type of oxidation zone in question develops, primarily on the composition of the ores and the country rocks. The most distinct zonality is found in mica oxidation zones.

The following stages of secondary uranium silicates formation - 1) hydroxide-silicate stage, 2) mica stage, and 3) silicate-proper stage - can be traced especially distinctly in hydroxide-silicate and silicate-mica oxidation zones. --Auth. (transl.).

1-1020. Tishkin, A. I., G. A. Tananayeva, G. D. Gladishev, I. V. Melnikov, V. A. Polikarpova, and M. S. Tsibulskaya. PARAGENETIC ASSOCIATIONS OF HYDROTHERMAL URANIUM MINERALS IN URANIUM DEPOSITS OF THE SOVIET UNION: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 445-65, 19 photomicrographs, diag., Geneva, United Nations, 1958.

U deposits in the Soviet Union are located primarily in acidic effusive and intrusive rock. They are less frequent in medium-composition effusive rock and metamorphic rock, and are extremely rare in basic rock of gabbrodiorite composition. Most U deposits were formed in many stages and over a long period of time. U mineralization occurred during the concluding stages of mineralization. U ore bodies fill open cavities, are vein or stockwork bodies, or are metasomatic in origin. Alkali metasomatism and carbonatization are among the processes especially close to U ore formation.

Studies of U deposits have shown that sometimes the containing rock and substances of earlier hydrothermal veins have essential influence on the composition of ore bodies. In Soviet deposits, the most common are uranium oxide paragenesis, especially paragenetic association of pitchblende with sulfides, among which the pitchblende-molybdenite paragenetic association is widespread. There is also considerable paragenetic association of pitchblende with calcite. Other paragenetic associations are limited.

A study of mutual reactions of paragenetic pitchblende and pre-pitchblende minerals allows the conclusion that there are quite varied conditions in which the mineral formation processes occur. In some deposits, the oxidizing effect of U-bearing solutions on earlier minerals is clear; in others, the pre-pitchblende minerals contact with the U-

bearing ores with no sign of corrosion or oxidation. Consequently, hypogenetic U minerals can segregate from hydrothermal solutions in quite a broad range of oxidizing-reducing conditions.

Depending on conditions in which mineral formation processes occur, U is included in varying proportions of U^{+4} and U^{+6}. In the silicate paragenetic association, the main U mineral is a silicate of tetra- and hexavalent U with extremely variable proportions of U^{+4} and U^{+6}. Considerable U masses have also been established in minerals paragenetic with nenadkevite. Uraninite is characteristic for uranium oxides, and to a lesser degree, pitchblende. In pitchblende-carbonate, pitchblende-sulfide, pitchblende-diarsenide, and pitchblende-halogenide (fluorite) paragenetic associations, the main U mineral is pitchblende, and the minor constituent is uraninite. As in the uranium silicates, the ratio of U^{+4} and U^{+6} in these minerals varies within quite wide limits. In iron oxide paragenesis, UO_3 sharply predominates in the pitchblende composition; in paragenesis with sulfides, the amount of UO_2 increases. --From auth. concl.

1-1021. Bhola, K. L., B. D. Chatterji, K. K. Dar, and others. A SURVEY OF URANIUM AND THORIUM OCCURRENCES IN INDIA: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 100-102, Geneva, United Nations, 1958.

Indian occurrences of radioactive materials are located in Jaduguda, Bihar; in central Rajasthan; at Umra and Udaisagar, near Udaipur City; at Bhunas, Rajasthan; in beach sands along the coasts of Kerala and Madras; in black-sand concentrates along the E. coast; and in placer deposits in Bihar and West Bengal. Mineralization generally consists of uraninite, in places altered to autunite, torbernite, and metatorbernite. The Bhunas prospect consists of a zoned pegmatite which is also a commercial source of ruby mica and minor quantities of beryl. Beach placers contain monazite associated with ilmenite and other heavy minerals. The E. coast sands, unlike those of the W. coast, occasionally contain magnetite or garnet as major constituents. Inland placer deposits are of mineral composition similar to those of the beach deposits but also contain columbite-tantalite, uraniferous allanite, traces of barite, cassiterite, and possibly celestite. --G. E. Denegar.

1-1022. Bhola, K. L., G. R. Udas, N. R. Mehta, and G. H. Sahasrabudhe. URANIUM ORE DEPOSITS AT JADUGUDA IN BIHAR STATE, INDIA: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 704-708, 3 maps, sec., Geneva, United Nations, 1958, 8 refs.

Among the several prospects for U minerals under investigation in the Cu belt of Singhbhum in the State of Bihar, 2 large continuous deposits of the order of 2 million tons each have already been indicated by bore holes and partly proved by development work. One of them at Jaduguda is discussed in this paper.

The surface ore consists mostly of secondary minerals autunite and torbernite, but at depth uraninite takes their place. Commonly associated minerals are apatite, magnetite, and ilmenite. Hematite seems to replace magnetite in the surface and near-surface ore. Locally, copper sulfide minerals are also associated as in the Mosaboni Cu mines, the mill tailings showing small but appreciable activity. Traces of Zr and V are also present.

The country rock is the phyllite-quartzite suite of the Dhanjori stage in the Iron-ore series of Archean age. The mineralization is confined to a shear zone generally marked by elongated and somewhat recrystallized chalcedonic pebbles embedded in a chloritic matrix, the shears being connected with a major thrust which followed the intrusion of a soda granite which is believed to be the source of mineralization. The origin of the conglomerate, which is the host rock, is discussed, and an autoclastic origin ascribed to it.

Strikewise, the ore body has already been proved over a length of 3,500 ft. and vertically to a depth of 1000 ft. The ore body is of a variable thickness ranging between 15 ft. to 3 1/2 ft. It behaves as a continuous sheet with a general northerly dip of 55°. The deep bore holes generally show an enrichment of U with depth. Bore-hole operations continue to extend the limits of the ore body both along the dip and strike.

The effective quantity of explosives used during blasting operations in the separation of barren pebbles from the mineralized matrix has been investigated. This may have an important bearing on upgrading the ore by simple mechanical process.

The leaching process applied to the milled surface ore had to be modified for treating the unaltered ore. Combined gravity and magnetic separation form the main part of the process of beneficiation. --Auth.

1-1023. Dar, K. K., and H. Nandi. URANIUM DEPOSITS OF CENTRAL MEWAR: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 696-703, 3 maps, table, Geneva, United Nations, 1958, 4 refs.

Among the more recent finds of U ore in the Aravalli phyllites and schists of Rajasthan, mention should be made of (1) the pitchblende deposit at Umra and (2) U ore of Udaisagar, both on the eastern flank of the Aravalli geosyncline [India].

At Umra, the country rock is a black to gray chlorite-phyllite. It is occasionally associated with partings of carbon-phyllite and contains discontinuous lenses of dolomitic limestone towards the upper part of the succession. The phyllite series is succeeded [by] dolomitic limestone. The rocks are isoclinally folded with a general easterly or southeasterly dip. The phyllite-limestone contact on the W. bears the impress of local movement. An anticlinal fold with a high southerly pitch is recognized in the phyllite in the immediate neighborhood of the limestone contact where surface indications of mineralization were observed. Additional ore bodies have been located further E. on 2 other strike ridges of similar phyllite. Old Cu workings and malachite and rarely azurite staining are present in the area. The major U mineralization is however independent of the Cu lodes though some activity is noted in the old Cu workings. In the early stages of pitting and trenching ore analyzing 5 to 10% and even up to 37% was obtained. Core drilling however proved it to be discontinuous as 70% of the holes did not pass through the dip extension of the ore seen at the surface, though some fresh mineralized zones were picked up. Adits run at depths of 50 to 70 ft. below the outcrop level have yielded a better picture of the deposit. Several new ore shoots and mineralized shear zones 4 to 5 ft. wide have been encountered.

The data furnished a basis for a revised drilling and development program. The primary ore is pitchblende/uraninite, cubical crystals of the latter being visible to the naked eye and in thin and polished sections. The minerals accompanied by rims of orange and yellow gummite sometimes occur in one to a quarter-inch thick massive veins in highly discolored, structureless, and dense clayey substance of a pinkish-cream, buff, or light-green color, being an alteration product of phyllite. Torbernite and autunite are also commonly met with at or near the surface.

A number of prospects have been located in the neighborhood of Udaisagar. The geology of the 2 areas is similar... As at Umra, the area bears traces of Cu ore. Uraninite occurs mainly in the chlorite-phyllite near its junction with the overlying carbon-phyllite, and also along planes of fracture in the silicified zones in which the mineral was precipitated along with manganese and iron oxides. --Auth.

1-1024. Udas, G. R. OCCURRENCE OF URANIUM IN PEGMATITE IN RAJASTHAN, INDIA: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 709-12, sketch map, sec., 3 tables, Geneva, United Nations, 1958.

Generally pegmatites are not looked upon as commercial sources of U. Recently, however, one has come under investigation which within 100 ft. of depth and a strikewise extension of 300 ft. is estimated to contain about 10 tons of U_3O_8. The uraninite pegmatite is zoned and occurs at Bhunas in Rajasthan [25°13'30"N. 74°22'30"E.] and is intrusive into the Aravalli schists of Archean age. From its hanging-wall contact with the mica schist inwards, ruby mica of commercial quality is prevalent. Further inwards and towards the footwall side of the mica working occurs a shear zone with a predominance of green mica of no commercial value. Microcline is the characteristic feldspar in the green-mica zone.

The U minerals in the green-mica zone are cyrtolite and uraninite. They sometimes occur in large chunks weighing as much as 40 lbs. Smaller grains occur as disseminations in the matrix, and uraninite particularly as fine particles in between mica lamellae. The associated quartz is generally smoky and translucent. Minor quantities of autunite and rarely metatorbernite appear as stains on other minerals. Petrological investigations and the study of autoradiographs revealed that uraninite occurs as minute stringers also within cyrtolite; uraninite can be separated by crushing the ore to minus 80 mesh.

Chunks of uraninite and cyrtolite that can be easily handpicked constitute roughly 1% of the run of the mine ore. It is fairly easy and reasonably economical to remove large lumps of barren quartz and feldspar and obtain a concentrate of an average 0.25% grade. Further concentration of the material to a grade containing 3% of U_3O_8 has been effected by gravity separation at 85% recovery.

Following the clue offered by this mineral association at Bhunas, pegmatites in the district are being re-examined, and already several new occurrences have been brought to light where detailed investigations are now in progress. --Auth.

1-1025. Mahadevan, C. BLACK SAND CONCENTRATES ALONG THE EAST COAST OF INDIA: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 716-19, Geneva, United Nations, 1958, 20 refs.

The paper reviews the results of a systematic study of the black-sand concentrates occurring along the Andhra coast over a length of about 350 mi. [from about 13°33'-19°N.] which disclosed several patches of concentrates of black sands along the beach down to a depth of about 5 ft. The heavy minerals consist of ilmenite, magnetite, sillimanite, garnet, zircon, monazite, etc. Detailed studies of beach profiles carried out in areas of beach-sand concentrates clearly indicate that the extent of deposition of heavy minerals and the degree of their concentration at a given place are influenced by the major factors of river flow, tides, waves, and currents, and changes of sea level. The beach concentrates are found to be richest after monsoonic months (Nov.-Feb.) and poorest in summer. Minerals derived from the drainage basins of streams emptying themselves into the Bay of Bengal as well as inshore sediments are known to be the source material for the beach-sand concentrates. --Auth.

1-1026. Mahadevan, V., G. R. Narayana Das, and N. Nagaraja Rao. PROSPECTING AND EVALUATION OF BEACH PLACERS ALONG THE COASTAL BELT OF INDIA: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 103-106, 2 maps, table, Geneva, United Nations, 1958, 2 refs.

The Atomic Minerals Division has been engaged, since 1950, in the survey of the beach sands on the southwestern coast of India. The reserves of monazite, up to a depth of 25 ft. have been estimated at 1.4 million tons, and those of ilmenite at 52.5 million tons. It is, however, not known to what further depth workable concentrates may be found.

Preliminary survey has indicated the presence of monazite and other heavy minerals on the sea bed within half a mile of the W. coast and also on the beds of inland lakes. The proportion of heavy minerals is lesser on the E. coast.

The hinterland, consisting of gneissic crystallines, heavily intruded by the pegmatites, is the primary source of the heavy minerals. The drainage pattern, topography, climate, and coastal configuration determine, to a large extent, the deposition of these placer minerals.

For delineation of the zones containing appreciable monazite, samples are drawn at regular intervals in a grid pattern, the weight percentage in each sample is plotted against the respective grid station, and isopach lines are drawn to demarcate the barren from the rich zones.

Reserves are calculated following conventional procedures. --Auth.

1-1027. Shirke, V. G., and B. D. Chatterji. MONAZITE SANDS OF BIHAR AND WEST BENGAL: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 713-15, 2 maps, 2 tables, Geneva, United Nations, 1958, ref.

Large monazite placers with other associated minerals, e.g., ilmenite, rutile, sillimanite, zircon,

etc., are known to occur on the western and eastern seaboards of India. Lately, similar sands have been discovered in inland areas in the older alluvium capping the Ranchi plateau in Bihar, in similar formations in the extensive low-lying plains of Kolebira to the S., in parts of Hazaribagh district to the N., in the plains of Purulia to the E., in the State of Bihar, and to a minor extent also in the adjacent areas in Burdwan and Bankura districts in West Bengal. Columbite-tantalite is often an additional constituent of the inland heavy-mineral sand in which rutile is also more abundant than ilmenite.

The blanket of brown to yellow older alluvium which rests on the Archean metamorphic complex has an average thickness of 4 ft. or so. It has partly given rise to soil formation with the segregation in it of ferruginous and calcareous pans. Sometimes, the in situ weathered mantle of bedrock shows similar concentration of heavy minerals.

The Archean basement, consisting of gneisses and schists intruded by acid rocks, is the ultimate source from which the minerals have been derived. Monazite is a minor constituent of the acid rocks, but it occurs in larger grains and in greater abundance in the mica schists into which it was introduced by the acid intrusives.

A program of sampling has been introduced on the basis of isorad maps which roughly demarcate the in situ active from non-active areas, and also according to different orders of activity in the active patches. Much barren area has thus been eliminated, and sampling is being confined to areas of higher activity only. The survey is not yet complete, but the work done so far indicates that the concentrates are economically workable over 20 sq. mi. in the portion of the belt already surveyed. --Auth.

1-1028. Katayama, Nobuo. GENESIS OF THE URANIUM DEPOSIT IN TERTIARY SEDIMENTS IN THE NINGYÔ-TÔGÉ AREA, WESTERN JAPAN: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 402-406, Geneva, United Nations, 1958, 11 refs.

The Ningyô-tôgé U deposit is characterized by the following features: (1) its age is very young, presumably late Miocene or early Pliocene; (2) it is a bedded deposit in basal conglomerate and lacustrine sediments; (3) it contains no workable metal other than U; (4) the effect of circulation of water along the faults cutting the ore deposit is visualized by secondary autunite; and (5) leaching and secondary enrichment by ground water just below the present surface of the earth are revealed at the outcrops of the deposit.

These features will make contributions to the studies of other U deposits in sedimentary rocks as well.

The writer's interpretation of the genetic environment of the U deposit is as follows:

In a terrestrial basin in a peneplained granite region, a conglomerate bed had been deposited, and there was a small lake in a trough upon the bed. Except the lake area, the surface of the conglomerate bed had been exposed to weathering and was covered by soils with beech forests. Both the lake water and the ground water in the conglomerate bed were stagnant. The surface or subterranean water pouring itself into the basin from the surrounding granite region contained a small amount of U in solution which was precipitated, accompanying iron sulfides, presumably by the action of hydrogen sulfide. In the case of the lake water, U was deposited as it was absorbed by clay minerals, while, in the case of the ground water, it was occasionally concentrated in intimate association with carbonaceous matter. After considerable deposition of U had been performed, volcanic activity took place in neighboring area, the lake spread over the whole basin, and the concentration of U came to an end.

In this paper the writer gives an account of those features and interpretations with reference to their basic data, and discusses them in comparison with those of the U deposits of the Colorado Plateau type or of the Witwatersrand type. --Auth.

1-1029. Murakoshi, Tsukasa, and Kôji Koseki. SUMMARY OF GEOLOGY AND MINERALOGY OF THE URANIUM AND THORIUM DEPOSITS IN JAPAN: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 720-31, 14 figs. incl. photomicrographs, maps, secs., Geneva, United Nations, 1958, 23 refs.

For a number of years, the occurrences of U and Th minerals known in Japan were limited to those of pegmatitic origin, and almost all of them were merely of mineralogical or geochemical interest.

At present, various types of U and Th deposits are known in Japan, and they include not only those of the above-mentioned types of pegmatitic origin, but also deposits which were considered to be lacking in Japan, such as the sedimentary deposits and those associated with metallic ore deposits. All of these new discoveries were made by exploration and research carried out during the last 2 or 3 years.

Although the types of some of the deposits are not yet clarified definitely and further revision may be necessary, the classification and the examples of the U and Th deposits of Japan are as follows:

1. Pegmatite deposits.
2. Pneumatolytic to hypothermal deposits.
   a) Tungsten type.
   b) Molybdenum- tungsten type.
   c) Molybdenum type.
3. Pyrometasomatic deposits.
4. Hydrothermal deposits.
   a) Nickel-cobalt-bearing-molybdenum type.
   b) Copper-arsenic-pyrrhotite type.
   c) Copper type.
   d) Gold-silver type.
5. Sedimentary deposits.
   a) Lacustrine deposit.
   b) Swamp deposit.
6. Placer deposits.

In this paper, the results obtained by geological and mineralogical researches on the main deposits of each type are summarized. --From auth. abs.

1-1030. Sato, Motoo. ON THE RESULTS OF PROSPECTING FOR PROMISING URANIUM DEPOSITS IN JAPAN: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 110-17, 3 illus., 6 maps, 2 cross-secs., table, Geneva, United Nations, 1958.

The discoveries of U deposits of non-pegmatite type in Japan have been reported from 40 localities in the past 3 years. Several of these localities which are regarded as promising U resources are being prospected in depth by means of underground driving. The outline of the results of the prospecting is as follows:

The Ningyo-toge U deposit occurs in the basal conglomerate of Neogene Tertiary stratified almost horizontally on a granite basement. This U-bearing conglomerate, extending over 7,000 m. from E. to W., is distributed nearly persistently on the peneplain of the Chugoku massif.

In the Ningyo-toge area, it is being proved that chemical prospecting by surface-water determination is effective for tracing the distribution of deposits. At present, prospecting galleries are driven in some part of the area. And, as a result, it has been known that U concentration is observed in hollows of the unconformity plane, namely in presumable channels of an ancient lake bottom, judging from the correlation of isobathic contours of unconformity plane and assay map.

Autunite is crystallized in outcrops and places where surface overburden is thin, and even in depth it occurs locally in faulted zones forming a small bonanza. U is contained generally more in the conglomerate of small pebbles than in that of larger pebbles.

The Atomic Fuel Corporation is also conducting underground prospecting of vein-type deposits in granite areas such as Kurayoshi, Tottori prefecture, Miyoshi, Okayama prefecture.

In the areas of Kurayoshi and Miyoshi, coffinite was found at the depth of 40 to 50 m. below the surface where zeunerite or autunite had already been found.

For the tracing of those veins occurring in sheared zones of granite, electric prospecting such as resistivity method has proved to be effective.--Auth.

1-1031. Higazy, R. A., A. G. Naguib, S. Abuzeid, and A. Khattab. THE DISCOVERY OF URANIUM ORES IN EGYPT: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 97-99, cross-sec., Geneva, United Nations, 1958.

Geological and radiometric surveys in both the eastern and western deserts are described. Results of discoveries in each area are given as follows:

1. Impregnations of uraniferous-siliceous solutions are discovered in Oligocene formations in Katrani area, Western Desert. Detailed chemical and mineralogical studies of the ores are given together with an attempt to correlate their genesis to the Tertiary volcanic activities known to have occurred in the vicinity.

2. Parts of the Miocene and Cretaceous formations of the Eastern Desert are surveyed. Uraniferous mineralization in Cretaceous marls is recorded. A discussion of the U mineralization in these marls as compared to that in the overlying phosphatic beds is given. Detailed chemical and mineralogical studies are given; possible origin of maximum mineralization is considered.--Auth.

1-1032. Higazy, R. A., and A. G. Naguib. A STUDY OF THE EGYPTIAN MONAZITE-BEARING BLACK SANDS: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 658-62, 2 illus., 2 maps, sec., graph, Geneva, United Nations, 1958.

Geological and radiometric surveys along the whole Mediterranean beach of the Nile delta proved the occurrence of differential deposition of the various minerals of black sands. The nature of deposition of black sands are described. Mineralogical composition and mechanical analyses of different samples are given. A discussion of the nature of deposition of the black sands is included.--Auth. pref.

1-1033. Derriks, J. J., and R. Oosterbosch. THE SWAMBO AND KALONGWE DEPOSITS COMPARED TO SHINKOLOBWE: CONTRIBUTION TO THE STUDY OF KATANGA URANIUM: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 663-95, 29 photomicrographs, 7 maps, 8 secs., diag., graph, table, Geneva, United Nations, 1958, 5 refs.

Swambo is a small deposit discovered recently to the W. of Shinkolobwe. The known mineralization is localized in a brecciated fault zone cutting across a "scale" of the Mine series. This "scale" is part of an anticlinal zone which can be followed from Shinkolobwe to Kalongwe, and along which outcrops belonging to the "schisto dolomitique" system occur. The discovery of the deposit is due to the application of radiometric methods. A preliminary drilling campaign has shown that the pay ore extends at least to 125 m. below the surface, the investigation not having been pushed beyond that depth. The underground workings have been developed as deep as the watertable, i.e., over 60 m. From a genetic point of view, the deposit is comparable to Skinkolobwe, but it is far from having the scope of the latter, although development possibilities are still encouraging.

Kalongwe is a cupro-cobaltiferous deposit located SW. of Kolwezi. The existence of a uraniferous mineralization there has been known since 1931; it is located principally along a fault which cuts through a small spur of the Mine series. The R. A. T. Gr. beds at the base of the Mine series are also impregnated with black pulverous uraniferous oxides, in the vicinity of the fault. The mineralization has been recognized by drilling to a depth of 60 m.; the drill holes have also reached a deep spur showing traces of radioactive ore. The deposit has been developed by underground workings to a depth of 42 m. The possibilities of any extension are modest, and the chances of a paying mine seem to be mediocre. The succession of metalliferous deposition is comparable to that of Shinkolobwe, but the Kalongwe deposit distinguishes itself by the relative abundance of Cu and the practical absence of Ni.

The study of the deposits at Swambo and Kalongwe has not weakened the conclusions drawn from the more extensive work carried on at Shinkolobwe. The presence of Ag, Zn, and Ge in this latter deposit - in minute quantities - poses new problems of genesis which must hold the attention. They cannot be studied until after the most ample observations in the deposit itself.

The development of the Eastern Extension has allowed an increase in the Shinkolobwe reserves, but it appears that the costs of extraction of this supplement will be raised to the point of compromising the profitablity of exploitation in the present U-market conditions.--From auth. abs. & concl.

1-1034. Lecoq, J. J., G. Bigotte, J. Hinault, and J. R. Leconte. PROSPECTING FOR URANIUM AND THORIUM MINERALS IN THE DESERT COUNTRIES AND IN THE EQUATORIAL FOREST REGIONS OF THE FRENCH UNION: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material

Resources, p. 744-86, 10 illus., 13 maps, table, Geneva, United Nations, 1958, 30 refs.

For the last 10 years, the Commissariat à l' Energie Atomique has launched U and Th prospecting campaigns throughout the Union Française Territories (French Africa, Madagascar, French Guiana) which cover a total area of about 11 million km.^{2}. Desert or subdesert regions constitute about 50% and dense equatorial forest over 10% of this area.

The study of the geological and structural characterics of these territories and their comparison to those of other U- or Th-bearing provinces of the world, show that most of them are worth prospecting in spite of these difficult circumstances. A review of the major setbacks to be coped with in excessive climate regions is given: difficulty of access; distances; effects on the personnel and equipment either of drought or of extreme dampness - in both cases, the European staff does not stand up long to the climate; exceedingly small resources in local labor; and either nonexistent or practically unobtainable local supplies. A discussion of the difficulties particular to U and Th prospecting follows.

In desert regions, thick dunes spread over wide surfaces. In equatorial countries, a continuous overburden covers the rocks, and outcrops are extremely rare. In these regions, moreover, the waters leach away surface U mineralization and carry them further on, giving rise to deceptive occurrences. The different techniques tried out in these countries by the C. E. A. are dealt with.

Prospecting is impeded by the scarcity of geological maps on a suitable scale. However, in the Sahara regions, which are being extensively covered by aerial photography, photogeology is very efficient. In forest-covered regions, photogeology seemed impracticable. In French Guiana, however, the problem has been solved.

The C. E. A. has undertaken extensive carborne or, more often, airborne (by plane or helicopter) scintillation surveys of vast areas. In desert regions, this technique is now well advanced. In equatorial forests, it is still a delicate matter, and its possibilities are more limited.

Ground prospecting is still useful enough, but it is rather slow in regions of difficult access amid excessive climate. The pan is mostly applied to Th research in alluvium. Ground radiometry requires sand-proof (desert) or highly moisture-proof (equatorial forest) equipment.

Geochemical methods (water, soils, alluvium) have been systematically tested, in French Guiana in particular. A description is given of the conditions in which these very extensive experiments were conducted, and of the conclusions drawn from them. As yet, all electric geophysical techniques in desert regions have failed. They can be applied in forest regions, around a proved occurrence, so as to determine the extension of the structures beneath a thick overburden. Prospecting through drilling, trenching, and mining requires a well-adapted equipment.

Finally, the efforts made to train local labor for the various prospecting works and the favorable results obtained are mentioned. --Auth. (transl.).

1-1035. Liebenberg, W. R. THE MODE OF OCCURRENCE AND THEORY OF ORIGIN OF THE URANIUM MINERALS AND GOLD IN THE WITWATERSRAND ORES: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 379-87, Geneva, United Nations, 1958, 19 refs.

Many theories have been advanced to explain the mode of occurrence and origin of the Au minerals in the Witwatersrand ores, Union of South Africa. Of these, 2 have survived as the most plausible. The hydrothermal theory postulates that the Au was deposited from solutions after the conglomerates were in position. The placer theory postulates that the Au was deposited simultaneously with the other constituents of the conglomerates, later being reworked and reconstituted in situ.

The Au-U ore consists of a compact metamorphosed conglomerate occurring as bands in a thick body of sediments, predominantly quartzites. The conglomerate consists mainly of pebbles of vein-quartz cemented by a fine-grained matrix composed principally of quartz and phyllosilicates. The valuable constituents are almost entirely confined to the matrix of the conglomerate. Some U and Au are present in banded pyritic quartzites in erosion channels which cut the bands of conglomerate.

Uraninite, occurring as oval detrital grains of an even small size, is the major U mineral. Some secondary uraninite, occurring as irregular patches and minute veinlets, is present. Minor thucholite, a heteorogenous hydrocarbon-uraninite mixture, is also present. Associated minerals include chromite, zircon, garnet, monazite, iridosmine, xenotime, apatite, rutile, pyrite, sulfides, chloritoid, etc.

Facts taken into consideration in discussing the origin and mode of occurrence of the U and Au minerals of this ore are:

1) Oval grains of uraninite form the basis of U mineralization.

2) Grains of uraninite behave like members of a heavy mineral suite in the conglomerates.

3) Secondary uraninite was formed at the expense of primary uraninite, not from hydrothermal solutions from an extraneous source.

4) Primary grains of uraninite were prerequisite for thucholite formation.

5) Uraninite, Au, and sulfides are not genetically related, as in polymetallic veins.

6) Au behaves like a member of the heavy mineral suite in the conglomerates.

7) Au and U minerals are virtually confined to relatively thin conglomerate bands in an immense body of barren sediments.

8) The mineral composition of the conglomerates in 4 different systems, deposited and compacted at different periods, is of uniform nature.

It would therefore appear that the placer theory more accurately describes the origin and mode of occurrence of the Witwatersrand ores. --G. E. Denegar.

1-1036. Nel, L. T. THE OCCURRENCE OF URANIUM IN THE UNION OF SOUTH AFRICA: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 54-86, 2 geol. maps, columnar sec., Geneva, United Nations, 1958, 43 refs.

The search for resources of U, following on the greatly increased demand for the metal, led to the discovery and exploitation of large low-grade deposits of uraninite in the conglomerates mined for Au in southern Transvaal and northern Orange Free State. According to a recent estimate, there are over 1,100 million tons of indicated ore with uranium

oxide content on the order of 370,000 tons. Other known occurrences of U minerals, mostly in pegmatites, in various parts of the country are unimportant for U production.

Uraninite is associated with Au, sulfides (chiefly pyrite), and other heavy minerals in conglomerates at various horizons of the Witwatersrand system and at the base of the Dominion Reef, Ventersdorp, and Transvaal systems. These 4 formations, unconformable to one another, are of Precambrian age. Source rocks of the Witwatersrand sediments, which produce practically all the U, are the Archean formations known to contain pre-Witwatersrand Au and other mineral deposits.

The distribution of U, and of Au, in these sedimentary formations is intimately related to certain lithological and structural features of sedimentary origin. Economic concentrations are confined almost exclusively to certain relatively thin conglomerate beds of which some, in the upper Witwatersrand beds, are remarkably continuous over long distances. The richest conglomerate or bankets generally lie upon planes of intraformational disconformities and unconformities. These bankets represent initial deposits formed after breaks in sedimentation and consist of reworked and reconcentrated detritus set free by the erosion of underlying rocks. Radiometric logging shows that radioactivity in varying degrees is exhibited by all the upper Witwatersrand quartzose beds, but abrupt, pronounced increases in radioactivity are confined to these conglomerates.

The U-Au contents of the bankets depend on the quantitites of these metals present in the rocks from which the bankets were derived. Similarly, high concentrations of uraninite and Au occur in the basal conglomerates of the Ventersdorp and Transvaal systems where they rest unconformably on or not far from the eroded edges of the Witwatersrand bankets. Stream-channel fillings below some surfaces of erosion reveal several features indicating that Au and uraninite concentrations in conglomerate beds forming part of the fillings are dependent on the presence of these ores in previously deposited conglomerates cut by the channels.

The bankets consist predominantly of quartz pebbles set in a quartzose matrix containing subordinate to minute amounts of minerals such as pyrite and a variety of other metallic minerals, hydrocarbon, sericite, and chlorite. Alteration of the matrix has produced secondary textural attack and replacement features reminiscent of hydrothermal ore deposits.

Au, uraninite, and pyrite mineralization does not extend beyond the limits of a conglomerate bed and across stratification into adjacent rocks. Careful and systematic sampling has shown that fractures, dikes, quartz, and occasional calcite veins bear no relation to the distribution of Au and U values except for occasional local enrichments or impoverishments of the values.

The origin of the uraninite and Au is in dispute. Collectively, the criteria available favor the syngenetic rather than an epigenetic origin. --Auth.

1-1037. Pike, D. R. THORIUM AND RARE EARTH BEARING MINERALS IN THE UNION OF SOUTH AFRICA: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 91-96, Geneva, United Nations, 1958, 3 refs.

The following Th- and rare earth-bearing minerals occur in the Union of South Africa: a) bastnaesite, calcium-yttrium silicate, fluocerite, monazite, parisite, xenotime, and zircon in vein deposits; b) allanite, cyrtolite, euxenite, fergusonite, gadolinite, microlite, pyrochlore, samarskite, thorite, uraninite, uranothorite, xenotime, and zircon in pegmatites; c) allanite, monazite, xenotime, and zircon as disseminations or syngenetic bodies in igneous rocks; d) thorite and uranothorianite in carbonatites; e) monazite, xenotime, and zircon in consolidated and unconsolidated sediments.

In the Vanrhynsdorp Division, Cape Province, several hydrothermal lodes of high-grade monazite ore occur in the Archean complex. The monazite is accompanied by apatite, zircon, Fe, and Cu minerals, and the ore as a whole replaces hydrothermally altered granite-gneiss along shear zones. The most important deposit is on Steenkampskraal, where the lode outcrops over a distance of 900 ft. and varies in outcrop width up to 13 ft. It dips steeply into the surrounding rock, and swells and pinches within the confines of the shear zone, reaching a maximum thickness of 30 ft. The lode persists to over 400 ft. in depth measured vertically from the surface. The average content of ThO_2 in the monazite is about 8%, and the grade of ore mined varies between 3 and 6% ThO_2. Ore-reserves of 250,000 tons were indicated by prospecting.

This is the only deposit which is being worked primarily for rare earths and Th. Other mineral deposits which may assume economic significance, either in their own right, or as by-products, are bastnaesite and calcium-yttrium silicate which occur in close association with cassiterite in the Potgietersrus tin field, Transvaal; allanite in granite gneiss, Gordonia district, Cape Province; monazite in fossil placer concentrates in the Ecca series, Bothaville district, Orange Free State; monazite in conglomerates of the Dominion Reef system, Klerksdorp district, Transvaal; and uranothorianite in carbonatite, Phalaborwa, Transvaal.

In rare instances, sufficient material can be won as a by-product from a restricted area of pegmatite mineralization; the rest of the known deposits are either too small or too sporadic to warrant development at this stage. --Auth.

1-1038. de Villiers, J. W. L., A. J. Burger, and L. O. Nicolaysen. THE INTERPRETATION OF AGE MEASUREMENTS ON THE WITWATERSRAND URANINITE: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 237-38, Geneva, United Nations, 1958, 8 refs.

The isotopic ages of certain uraninite concentrates from the Witwatersrand system [Union of South Africa] have been used by other workers as evidence supporting a detrital origin of the uraninite. This argument is critically examined in the light of new isotopic measurements. There is strong evidence that the minute uraninite grains have suffered extensive loss of radiogenic Pb, after their incorporation in the Witwatersrand system. It is concluded that, at the present time, age measurements on the Witwatersrand uraninites do not have a critical bearing on their detrital or epigenetic origin. More accurate data are required concerning the age of initial crystallization of the uraninite, and the age of deposition of this system. --Auth.

1-1039. Shabad, Theodore. THE SOVIET ALUMINUM INDUSTRY: 25 p., 2 illus., 4 maps, chart, 5

tables, New York, American Metal Market, Oct. 1958, refs.

Before 1932, the Soviet aluminum industry was in an experimental and pilot-plant phase, and requirements of this metal were being met by steadily increasing imports. The opening of the first Soviet aluminum plant in 1932 resulted in gradually declining imports and even exports. From 1932 to 1940, the industry slowly grew in European Russia, and in 1940 the total aluminum output was 60,000 tons. The largest aluminum plant at Zaporozhye had an annual output of 36,000 tons, the new Kamensk plant in the Urals accounted for 13,000 tons, and the Volkhov plant for 11,000 tons. The German attack in 1941 resulted in the move of the aluminum industry eastward to the Urals. Although the Soviet Union was thus able to salvage a large part of its aluminum capacity, it once more became dependent upon imports.

The post-war period, 1945-1955, was marked by 3 major developments: 1) continued concentration of bauxite and alumina production in the Urals, 2) imports of raw materials from Hungary, and 3) intensive reconstruction and new construction resulting in increased aluminum-production capacity.

Detailed Soviet foreign-trade statistics were published by the Russians for the first time since World War II in the summer of 1958. These figures make the Soviet Union the second largest exporter, after Canada. Current developments in the industry include the increasing use of non-bauxite materials such as the aluminum silicates nephelite, alunite, kyanite, and sillimanite as raw materials, and the continued gradual eastward shift of the industry in connection with the exploitation of new raw materials and electric-power sources in Kazakhstan and Siberia.

Also included is a gazetteer of mining and processing centers of the Soviet aluminum industry. -- G. E. Denegar.

1-1040. Wessel, F. W. ZIRCONIUM RAW MATERIAL SUPPLY: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 17-20, 2 maps, 3 tables, Geneva, United Nations, 1958, 8 refs.

Zr has risen to important status because its properties are peculiarly adapted to the field of nuclear technology and construction.

While zirconia is a significant constituent in 29 minerals, the zircon group is the principal material of commerce. Three deposits in Florida produce 90% of the domestic total, the remainder coming from South Carolina. Deposits have been noted in 24 states and Alaska. Reserves of 7,500,000 tons can supply the domestic market for 100 years at the apparent 1956 consumption rate.

Hf is present in all Zr-bearing minerals. In zircon, Hf/Zr ratios are from 0.01 to 0.36. Zr used in reactors must be Hf-free, since the latter has a cross-section of 105 barns; this property, however, makes Hf useful as control rods.

Since practically all zircon in the United States and abroad is derived from placer deposits, preliminary examination is simple; drive-pipe sampling and the more recent jet-drilling method are commonly used.

Various standard forms of placer mining methods are used, including floating and dry-land dredges, and dragline operations with truck haulage to a central plant. Beneficiation depends on magnetic and gravity separation; some use of dry electroconductor devices is made.

The technology of converting zircon concentrate to the finished pure metal for use in atomic reactors is, however, comparatively recent, and in this field improved and cheaper methods are to be expected. Alternate methods for 3 production steps have already made their appearance: pressure digestion of zircon in alkaline solutions, several techniques for Hf separation, and the use of Na in the reduction process.

One pound of Zr sponge, purified for atomic use, requires 3.87 lbs. of zircon. This figure may decline as scrap reclamation techniques improve. The present estimated annual capacity of Zr producers in the United States, principally in terms of reactor-grade metal, is 2900 tons. This would require 11,500 tons of zircon, or 1/9 of the estimated supply available in the United States during 1957.

End uses of zircon include ferroalloys, foundry sand, refractories, abrasives, ceramics, and chemicals. In 1955, consumption for metal manufacture chiefly reactor-grade Zr, required about 1/6 of the available supply; it seems probable that only continued decline of the price of the metal, as a function of improving technology, will cause a significant increase in the proportion of zircon used to make metal.

Australia leads in the production of zircon, and with the United States, accounts for over 90% of the world's production; small amounts are produced in Africa and South America. During 1957, nearly half of Australia's production was shipped to the United States.

Specifications for concentrates, both domestic and Australian, are in the range of 65 - 67% ZrO_2. Prices for imported material during 1957 averaged $28.40 per gross ton f.a.s Australian ports; early 1958 quotations were $50 to $51 per gross ton c.i.f. Atlantic coast ports. Recent domestic prices were $50 to $55 per short ton. Imports are tariff-free.

The outlook is for gradual increase in the use of Zr for nuclear reactors, which will find its greatest expression in marine power plants where space and weight are important considerations. --Auth.

1-1041. Hodder, R. W. ALKALINE ROCKS AND NIOBIUM DEPOSITS NEAR NEMEGOS, ONTARIO: Canada, Geol. Survey, Paper 57-8, 15 p., illus., 1958, 4 refs.

This report briefly describes an occurrence of alkaline rocks in a peculiar circular structure some 3 mi. in diameter in the Sudbury district of Ontario. The alkaline rocks occur in Precambrian granitic gneisses and are in concentric layers, although the eastern part of the structure is imperfectly known. The outermost layer consists of coarse-grained, equigranular syenite. Within this is a narrow discontinuous layer of ijolite succeeded or surplanted by a layer of dark foliated rock. Within this, although in part interlayered with it, is a layer of equigranular nepheline syenite about a core of coarse-grained syenite. All these concentric layers appear to dip steeply inward.

Within the outer layers of the alkaline body are ellipsoidal bodies up to 200 ft. wide and 500 ft. long composed principally of coarse-grained magnetite and apatite, with minor amounts of pyroxene, nepheline, magnetite, and pyrochlore. The mineralized bodies are still in the early stages of development but there appears to be many millions of tons of rock containing up to 0.26% Nb_2O_5 as well as apatite and magnetite. --H. M. A. Rice.

1-1042. Norton, J. J., W. R. Griffitts, and V. R. Wilmarth. GEOLOGY AND RESOURCES OF BERYLLIUM IN THE UNITED STATES: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 21-34, 2 maps, cross-sec., graph, 8 tables, Geneva, United Nations, 1958, 45 refs.

Beryl has been the only commercially important Be mineral. The United States produced about 7% of the estimated 95,000 tons of beryl mined in the world from 1935 to 1956. Larger sources have been Brazil, Argentina, India, and the southern part of Africa. Most of the domestic beryl has been obtained as a by-product or co-product of mining from zoned pegmatites in South Dakota, New Mexico, Colorado, and New England. One vein deposit in Colorado has been a source of beryl and bertrandite.

Beryl is obtained from relatively small mines and has been concentrated only by hand-sorting. Flotation with petroleum sulfonate is a promising future method of concentration.

Other Be minerals that have been marketed are chrysoberyl and bertrandite. Helvite is a potentially valuable mineral in some contact-metamorphic deposits. Be has also been detected as a minor constituent of many rock-forming minerals.

Be is concentrated with alkalies and volatiles in rocks belonging to the late phases of magmatic processes. A few granites and feldspathoidal rocks contain as much as 0.01% BeO. Higher concentrations occur chiefly in granitic pegmatites, but are also in a few contact-metamorphic deposits and quartz veins.

In zoned pegmatites beryl may appear in several units, but ordinarily it is most abundant in some single zone. It is richest in outer zones containing quartz, plagioclase, and muscovite; in intermediate zones containing quartz and plagioclase with or without muscovite, perthite, amblygonite, or spodumene; and in zones that are contiguous to quartz cores.

The very large bodies of spodumene-rich pegmatite in the Sn-spodumene belt of the Carolinas contain approximately 0.4% beryl. The beryl occurs as small, evenly distributed crystals that may be recovered by milling in the future.

A beryl-quartz vein has been mined at Lake George, Colorado. Beryl also appears in other quartz-rich veins, especially those that contain W and Sn. A few tactite deposits in the western states contain Be in helvite, commonly accompanied by F and W.

Known pegmatite deposits in the United States with 1% or more beryl have reserves of approximately 9,000 tons of beryl. Lower-grade deposits with 0.2 to 1% beryl, mostly in the Sn-spodumene belt of the Carolinas, contain at least 200,000 tons of beryl.

The known non-pegmatitic deposits of equivalent grade contain a much smaller quantity of Be. Furthermore, the Be is recoverable only by techniques that have not yet been adapted to commercial use. The most promising deposit is the helvite occurrence in tactite at Iron Mountain, New Mexico.

Though Be surely will never be a major metal in terms of tonnage used, the supply can be expanded if milling becomes economically feasible. Deposits yet to be discovered may be equivalent in grade to those already known, but no evidence suggests that higher-grade deposits are likely to exist. --Auth.

1-1043. Wadia, D. N. OCCURRENCES OF BERYLLIUM AND ZIRCONIUM IN INDIA: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 107-109, Geneva, United Nations, 1958, 4 refs.

Beryllium: There are nearly 20 Be-bearing minerals, but of these beryl is the principal commercial ore carrying a maximum of 14% BeO (5% Be). Indian beryl has a consistently high proportion of 11 to 13% BeO. Generally, the occurrence of beryl is confined to pegmatite dikes, of a highly capricious nature, in acid granites and gneisses of the Dharwar basement complex (Huronian); the exact age of the pegmatite is, however, believed to be post-Delhi (Algonkian). Its frequent associates are albite, microcline, muscovite, and accessories containing Li, Nb, Ta, and other rare-earth metals. The more productive beryl deposits are found in Bihar, parts of Rajasthan and Madras. Here beryl occurs at the edges of the prominent quartz cores of pegmatites and in the felspathic rims surrounding them. Columnar beryl crystals 15 to 20 ft. long, 4 ft. across, and weighing over 20 tons have been mined. Green and blue are the commonest colors, but white, amber, rose, orange, brown, and even black beryl are known. Be is of primary magmatic origin in these rocks. There is no evidence of hydrothermal origin, nor of its genesis from basic magmas. Production of beryl in India was insignificant before the war, but, since 1949, the annual output has been in some years 2000 to 3000 tons. Since 1946, an embargo on export exists, the output being stockpiled. A factory for manufacturing atomically pure Be and BeO is being planned. A large part of beryl mined in India is eluvial, or quarried from shallow pits. Underground mining of beryl as a side industry of the more highly remunerative mica mining is now responsible for major part of the output. The output from the mines rarely needs dressing or beneficiation treatment. For a mineral of such capricious distribution in nature, future supplies will depend on adoption of mining methods suited to its peculiar habitat and new techniques of prospecting. Ordinary drilling for so illusive a product in a host which is itself very patchy, does not answer, but geochemical tests with spectrographic and radioactive methods for probing surface rocks may bring to light potentialities of yet undiscovered beryl pegmatites. The reserves in India are yet substantial, but increasing cost of production may limit supplies. Fortunately, beryl mining is tied up with mica production, and, as long as India preserves its lead as the world's largest producer of mica, a moderate but steady supply can be counted upon.

Zirconium: India possesses large reserves of zircon, the principal ore, in extensive detrital littoral deposits on the W. and E. coasts, associated with ilmenite and monazite. There are besides large placer deposits in some parts of Bihar. Zircon forms as much as 7% of these raw ilmenite beach sands and placers. A reserve of considerably over 15 million tons is estimated. Baddeleyite and cyrtolite occur but are of no commercial importance, as also zircon excretions as primary constituents of some granitic and monzonitic rocks in Kerala and Madras. The production of zircon, fitfully varying from a few hundred to a few thousand tons, is from the nonmagnetic tails left in the processing of ilmenite and monazite beach sands at Travancore. The most frequent associates of zircon are ilmenite, arizonite, monazite, rutile, sillimanite, garnet, baddeleyite, cheralite, and thorite. Travancore zircon contains over 2.5% Hf as a constant ingredient. --Auth.

1-1044. Bradbury, J. C. BARITE IN THE SOUTHERN ILLINOIS FLUORSPAR DISTRICT: Illinois, State Geol. Survey, Circ. 265, 14 p., fig., table, 1959, 10 refs.

Barite occurs in association with fluorspar in the Hardin-Pope County mining district of extreme southern Illinois. It usually has been considered a gangue mineral, but recent interest in the possibility that commercial concentrations may be present has prompted this investigation. The barite occurs in places throughout the entire mining district and is found in both the vein and bedded replacement types of fluorspar deposits. However, its distribution is spotty, and its concentrations are of such size as to appear to be of possible commercial significance in only a few areas. Such occurrences are described, and suggestions are made for prospecting. Chemical analyses of barite and barite "ores" from various parts of the district are given. -- Auth.

1-1045. Hutt, G. M. PROSPECTOR'S GUIDE TO INDUSTRIAL MINERALS IN CANADA: 42 p., Montreal, 1958.

A pocket-size discussion of industrial minerals and rocks in dictionary form for use especially by the Canadian prospector in the field. It gives identifying characteristics of all but the most common minerals, indicates their mode of occurrence, suggests geologically and economically favorable Canadian areas for prospecting, discusses desirability of discovery, and suggests action to be taken when a discovery is made. It lists dozens of industrial mineral users. --Auth. (courtesy Ceramic Abstracts, Feb. 1959, p. 70)

The book is available from the author at 5127 Notre Dame de Grace Ave., Montreal, P.Q., Canada. Price $1.00.

1-1046. Burnham, C. Wayne. METALLOGENIC PROVINCES OF THE SOUTHWESTERN UNITED STATES AND NORTHERN MEXICO: New Mexico, Bur. Mines & Mineral Resources, Bull. 65, 76 p., 3 figs., 8 pls. (in pocket), 4 tables, 1959, 29 refs.

Some of the metallogenic provinces of southwestern United States and northern Mexico are defined by the geographic distribution of sulfophile trace elements in more than 500 samples of chalcopyrite and sphalerite from 172 mining districts.

Maps that show the geographic distribution of Sn, Ag, and the "combined metal content" in chalcopyrite, and of Ag and the "combined metal content" in sphalerite reveal 3 major belts of high trace-element content in the Southwest. These belts, which are here called the Eastern, Central, and Western metallogenic belts, are consistent in trend and position with a beltlike distribution of the major ore deposits of Cu, Au, Ag, and other metals. However, the deposits of a given metal tend to be concentrated in certain segments of the metallogenic belts; consequently, the metallogenic provinces, in the ordinary sense, are merely component parts of the larger beltlike features.

The metallogenic belts are generally consistent in position and trend with the major tectonic features, although they do not appear to be closely related in time. Hence, it is suggested that both the metallogenic belts and the major tectonic features are the effects of a more fundamental cause, which perhaps is a combination of compositional heterogeneities and associated physical discontinuities in the deep-seated source regions of the ores. --New Mexico Bur. Mines & Mineral Resources.

1-1047. United Nations, Economic Commission for Asia and the Far East. GEOLOGICAL SURVEY AND MINING DEVELOPMENT IN EUROPE AND IN THE USSR. REPORT OF THE STUDY GROUP OF GEOLOGISTS AND MINING ENGINEERS FROM ASIA AND THE FAR EAST 4 AUGUST - 5 NOVEMBER 1955: Its: [Mineral Resources Devel. Ser., no. 6], 215 p., 31 figs. (part fold.) incl. illus., maps, diags., 1958.

Geologists and mining engineers from Afghanistan, Burma, Hong Kong, India, Indonesia, and Japan studied mineral industries of the U.S.S.R., United Kingdom, France, and East and West Germany. The study of organization and planning of country-wide geological surveys included history of survey development, territorial and colonial surveys, special organizations, and legislation. Analysis of the training of geologists and mining engineers covered curricula, training problems, and inspection of various universities in countries visited. Aero-methods used in geological investigations, radioactive-mineral prospecting apparatus, and seismic, gravimetric, and other geophysical methods of prospecting were analyzed. Coal machinery plants, coal and oil fields, brown-coal mining operations, underground gasification of coal processes, research laboratories, and coal plants were examined. Fe, Mn, W, Mo, Sb, Hg, Pb, Zn, and Cu deposits were visited in the study of exploration and development of Fe ore and other mineral resources for ferroalloy metals and for nonferrous metals. Recommendations were made. --G. E. Denegar.

1-1048. de Villiers, John. SOME REACTOR MATERIALS OTHER THAN FUELS IN THE UNION OF SOUTH AFRICA: In: International Conference on the Peaceful Uses of Atomic Energy, 2d, Geneva, 1958. Proceedings, v. 2, Survey of Raw Material Resources, p. 87-90, map, Geneva, United Nations, 1958, 7 refs.

The Union of South Africa has few or no known deposits of B, Cd, and Re; modest reserves of Ni, Ta, and Mo, but somewhat larger reserves and a production potential of the ores of W and the rare earths. Three elements mentioned as reactor materials occur, however, in appreciable amounts. They are Be, V, and Zr.

Beryl, the ore of Be, is mined from granite-pegmatites in 2 main areas. One of the pegmatite fields is situated in the northwestern Cape Province where it constitutes a belt some 280 mi. long by 5 or more mi. wide. The localization of this belt is related to the regional metamorphism of the area. Another field is located in the eastern Lowveld of Transvaal, and the known beryl-bearing pegmatites occur on or near the concealed contact between gneiss to the S. and schist of the Swaziland system to the N. A feature of the beryl from both these localities is that it is often confusingly similar to either quartz or feldspar, with the result that for years it was not recognized. A potential third field is believed to be located in the gneiss of the Limpopo lowlands. Over the last nearly 8 years, an average annual production of 470 short tons of beryl has been maintained.

Large reserves of low-grade V ore, containing over 1% V_2O_5, are represented by the titaniferous magnetite of the Bushveld igneous complex in the Transvaal. Reserves in 2 belts, respectively 100

and 110 mi. long, are probably some hundreds of millions of tons. Production has commenced on the eastern belt.

Zr is found in economic quantities as baddeleyite in phoscorite ringing the carbonatite core of the Palabora igneous complex. From this an annual production of 3,000 tons as a by-product of the established phosphate undertaking would seem possible. On the E. coast, large quantities of "black sands" occur on the beaches and as dunes.

Exploitation of these for their Ti content has commenced, and some 10,000 short tons of zircon will be produced annually as a by-product. A reserve of at least 100,000 tons of zircon is known to be contained in beach and dune sands of the W. coast, but it is doubtful whether this source will be exploited in the near future. --Auth.

13. FUELS

See also: Geologic Maps 1-812, 1-817; Geophysics 1-899; Geochemistry 1-914, 1-916, 1-917; Mineral Deposits 1-984, 1-995.

1-1049. Clifford, O. C., Jr. THE REVOLUTION IN PETROLEUM EXPLORATION, 1955--: Geophysics, v. 24, no. 1, p. 1-11, 1959.

Text of the presidential address delivered before the 28th Annual International Meeting of the Society of Exploration Geophysicists in San Antonio, Texas, in Oct. 1958. The 3 factors which have had the most profound effect on petroleum exploration are the development of magnetic-tape recording, with electronic analysis of seismic data; the development of continuous acoustic logging devices; and the trend, not only on the part of American geologists and geophysicists but of all American labor, toward pricing itself out of the world market unless there are sharp increases in productivity.

Fuller and more effective communication is urged between laboratory and field, between geologists and geophysicists, between corporations, and across international and language barriers. As a step in this direction, the immediate amalgamation of various professional groups into an international Institute of Exploration Geoscientists, having appropriate sections on petroleum and mining geology and geophysics, is urged. Exchange of knowledge and experience is necessary in order to make more effective use of new tools. Finally, inhabitants of other countries should be trained in seismic and logging techniques; "here lies the path to world peace and world profit."--D.B. Vitaliano (courtesy Geophysical Abstracts, 176).

1-1050. Dickey, Parke A. 100 YEARS OF OIL GEOLOGY: GeoTimes, v. 3, no. 6, p. 6-9, 24-25; no. 7, p. 6-7, 24-25; 3 maps, sec., 1959, 35 refs.

Oil and gas have been known since time immemorial, but it was not until the 18th century that these substances and coal were all recognized as having been derived from living organisms. In the first half of the 19th century, oil came to be widely known and used as a fuel and lubricant. On Aug. 27, 1859, Edwin L. Drake, drilling on the site of an old oil spring near Titusville, Pennsylvania, struck oil. This was the beginning of oil wells.

As drilling proceeded, it became apparent that the oil fields lined up in long, narrow belts and trends. Early petroleum geology was marked by efforts of the Second Geological Survey of Pennsylvania to delimit these trends through topographic and structure-contour mapping, correlation of sands, and examination of sand samples. In the meantime, oil had been discovered in western Ontario in anticlinal structures. Oil seeps were noted on the very sharp Burning Springs anticline in western West Virginia. However, until the discovery of the Cushing field, Oklahoma, in March 1912, the anticlinal theory remained unused by oil men, simply because it did not apply to the principal oil fields of the time. A structure-contour map of the Cushing field, published by the Oklahoma Geological Survey in 1914, made a big impression on many producing companies. This established geology in the oil business.

Paleontology had been an important branch of geology since the early 1800's. In the early 1900's, the value of foraminifera in oil geology was recognized. An important recent development in petroleum micropaleontology is the use of fossil spores, pollen, and other very small fossils which can be extracted from cuttings with hydrofluoric acid.

In the 1880's, Baron von Eotvoes invented the torsion balance which measures the horizontal component of the earth's gravitational field. It was first used in oil prospecting in Czechoslovakia in 1915 and later in the United States, Indonesia, and South America. Many experiments on methods of determining the vertical component of gravity with pendulums were conducted, resulting in widespread use of this method of geophysical exploration, especially in the intermontane basins of the western United States. The miners' dip needle was modified for airborne geophysical prospecting. Measurements of the velocity of artificial seismic waves were used to determine the character and depth of subsurface formations. During the beginnings of geophysical prospecting in the 1920's, much attention was given to electrical methods. The electric log is now the most important single tool of the subsurface geologist and ranks with the seismograph as the most useful geophysical method of oil exploration.

The early geologists in Pennsylvania understood the effects of porosity and permeability and the role of gas and water in the production of oil. The injection of compressed air into oil sands to increase the flow was practiced before 1900. From 1859 to 1915, geologists were fully conscious of the effect of sand conditions in localizing oil pools. In the late 1930's, sedimentary factors were statistically treated to predict sand conditions in the same way structure contours were used to predict structure conditions. From these studies, stratigraphic prospecting became an oil-exploration tool.

Study of the origin and migration of oil has continued since 1870, but it is the area of greatest ignorance in oil geology. It is here that future progress will probably receive its greatest impetus. The discovery of a new principle like the anticlinal theory would revolutionize the whole art of oil prospecting. --G. E. Denegar.

1-1051. Lattman, Laurence H. GEOMORPHOLOGY - APPLIED TO OIL EXPLORATION: Mineral Industries,

v. 28, no. 6, p. 1-3, 8, March 1959.

This brief treatment emphasizes the value of geomorphic studies of aerial photographs and mosaics of oil exploration in the plains or "flatlands." Geomorphology is used as a guide to increase the speed and decrease the cost of geophysical methods of exploration.

Based on the fundamental assumption that the effect of geologic structures underlying the flatlands is continuously propagated to the surface, the geomorphologist examines aerial photographs for the subtle topographic influences of these structures. One of the most sensitive indicators of these topographic effects is drainage, the patterns, or individual channels, of which respond to the smallest topographic expression of structure. Tonal halos and lineaments seen on aerial photographs may also reflect underlying structures. The third, and potentially most important technique, consists of mapping short topographic, vegetational, and soil tonal alignments which indicate joints, faults, and shatter zones. The structural interpretation of these linear features is only recently being studied.

As exploration costs, especially in foreign concessions, increase, geomorphology is expected to become a more important method of preliminary reconnaissance for structures in flatlands.--Auth.

1-1052. Mirchink, M. F. THE PRESENT STATUS OF THE THEORY ON THE ORIGIN OF OIL AND TASKS FOR FURTHER INVESTIGATION[1]: Internat. Geology Rev., v. 1, no. 1, p. 73-101, Jan. 1959.

In this report are briefly set forth the highlights of the status of the present-day theories on the organic origin of oil, and a short survey is presented of various other hypotheses on oil formation, in particular the inorganic origin of oil.

Differing opinions on specific situations and unsolved questions under discussion are examined. The fundamental tasks for further investigation are outlined under the following major headings:

I. Historical sketch.
II. Practical significance of the problem.
III. Hypotheses of the inorganic origin of oil.
IV. The chief positions in present-day theory on the organic origin of oil.
  1. Circumstances pointing to the biogenic origin of oil.
  2. The problem of the original material and the conditions of its accumulation in sediments.
  3. The means by which organic matter is altered, leading to the formation of oil, and the factors defining the steps and direction of such alteration.
V. Differing opinions on specific situations; unsolved questions and questions under discussion.
  1. Differing views on the question of oil-bearing sediments.
  2. Differing views on factors determining the transformation of organic matter into oil or gas.
  3. The most important views on the question of the chemistry of oil formation and of the changes in the chemical composition of oil within the earth's crust.
  4. On the differing views of the question of the primary movement (migration) of hydrocarbons from the original oil-producing sediments into reservoirs.
VI. The chief tasks of further research.
  1. Questions requiring additional study.
  2. On the factors determining the transformation of organic matter into oil and the balance of energy in the transformation.
  3. On the problem of recognizing oil-producing formations.
  4. Questions of the formation of genetic types of oil.
  5. The study of the geologic laws of the storing of oil and gas deposits.

The report was drawn up under the direction of the Orgkomitet for the organization of discussion relating to the problem of the origin of oil.--Auth. introd.

[1]Published by the State Scientific-Technical Publishing House for Oil, Mining and Fuel Literature, Gostoptekhizdat, Moscow, 1958.

1-1053. Carsola, Alfred J. MARINE LIGNITE: Am. Assoc. Petroleum Geologists, Bull., v. 43, no. 3, pt. 1, p. 676-88, 5 illus., 3 maps, March 1959, 23 refs.

Whether or not lignite can be formed in a marine environment is the basis of controversy. Four examples suggesting that lignite can be so formed, not only as an admixture to terrigenous sediment, but also as separate thin beds, at least under special conditions, are as follows:

1. Nodales Channel, British Columbia. Poorly sorted mixtures of gravel, sand, silt, and clay contain echinoderm and mollusk remains and terrigenous plant material in water of weak salinity and tidal currents. Burial is rapid. Deposition in this type environment could result in sedimentary rocks interbedded with impure lignites.

2. Chukchi Sea, Alaska. Coal fragments, probably representing resedimentation of detritus from eroded coal beds, and remains of Recent terrigenous plants are found in cores as well as in surface seafloor samples in southeast Chukchi Sea.

3. San Diego region, California. Lignite is common in the lower Eocene Delmar formation and is frequently found in limestone composed principally of pelecypod shells, indicating transportation to final depositional site in water that was at least brackish.

4. La Jolla and Point Loma, California. Cretaceous marine sedimentary rocks contain lignitiferous mudstone. It is not clear whether the lignite was transported to the depositional site as such, or arrived as plant remains which were buried and subsequently lignitized.--G. E. Denegar.

15. MISCELLANEOUS

1-1054. Zumberge, James H. ELEMENTS OF GEOLOGY: 382 p., 241 illus., New York, John Wiley & Sons, Inc., 1958, 96 refs.

The principles of physical and historical geology are treated in an elementary way for the non-geologist. The first 4 chapters describe the earth, its place in the universe, geologic forces, and the origin of rocks and minerals. Chap. 5 deals with earthquake waves and the earth's interior.

Chaps. 6 through 11 are concerned with the various geological processes including weathering and soil

formation, work of wind, ground water, rivers, glaciers, and water waves. The remaining 6 chapters are devoted to a systematic treatment of the geologic history of the earth and its inhabitants from the Precambrian to the present, with most of the examples from North America. The doctrine of uniformitarianism is stressed throughout.

The book contains some ideas which ordinarily are not found in some of the newer American elementary geology texts, such as a fair treatment of continental drift and a simple modern account of the hydraulics of water wells.

Technical terminology is kept at a minimum. --Auth.

1-1055. Leet, L. Don, and Sheldon Judson. PHYSICAL GEOLOGY: 2d ed., 502 p., 410 figs., 29 tables, Englewood Cliffs, N. J., Prentice-Hall, Inc., 1958, 103 refs.

A thorough revision of the first edition published in 1954, this book is designed as a textbook for an introductory college course in physical geology. The concepts of chemistry and physics are incorporated where appropriate, but the geologic story remains the focus of the book. Twenty chapters include the major subjects of physical geology as well as a discussion of geologic time. A summary and list of selected references follow each chapter. A glossary defining about 500 geologic terms adheres as closely as possible to the usage in the American Geological Institute Glossary of Geology and Related Sciences. Appendices include the electronic configuration of the elements and a list of the elements; powers of ten; mineral characteristics and determinative tables; and topographic and geologic maps. End papers present generalized geologic sections across Canada, United States, and Mexico. --S. Judson.

1-1056. Cooper, S. A. CONCISE INTERNATIONAL DICTIONARY OF MECHANICS AND GEOLOGY. ENGLISH-FRENCH-GERMAN-SPANISH: 400 p., New York, Philosophical Library Inc., 1958.

Approximately 5000 mechanical and geologic terms are listed in English with translations in French, German, and Spanish. Three foreign indexes are provided. The contents are mainly based on general machine parts and mechanical terms, to which have been added varieties of coal, iron and steel, alloys, minerals, and geological expressions. The dictionary also contains the usual chemical reagents, metallurgical and mathematical terms, units of measurement, numerals, tools, drawing instruments, wood and timber trees. --G. E. Denegar.

1-1057. Bolostnova, M. B., comp. DICTIONARY OF RUSSIAN GEOGRAPHICAL NAMES. Transliterated and translated by T. Deruguine: 82 p., New York, Telberg Book Company, 1958.

Approximately 4500 Russian geographical names are listed in a word-for-word transliteration and/or translation of: Slovar Russkoi Transkriptsii Geograficheskikh Nazvanii. Chast I: Geograficheskie Nazvaniia na Territorii SSSR [Dictionary of Russian Transcriptions of Geographical Names. Part I: Geographical Names in the Territory of the U. S. S. R.], Moscow, 1955.

Each entry includes the geographical name in its transliterated form, unless the name has been generally accepted in English usage in a different form, in which case both are given; physical identification for landforms; location and area, such as autonomous republic, okrug, oblast, krai, etc., given as of Sept. 1, 1955; latitudinal and longitudinal coordinates with accuracy to one tenth of one degree.

To make this transliteration/translation directly referable to the Russian original, the geographical names have not been rearranged according to English alphabetical order but kept in the sequence of the original. --From preface by V. G. Telberg.

1-1058. Kansas, State Geological Survey. RESEARCH AND ACTIVITIES OF STATE GEOLOGICAL SURVEY OF KANSAS, FISCAL YEAR ENDING JULY 1, 1958. Its: Misc. Rept., 48 p., illus. (1 col.), maps, charts, graphs, Jan. 1959.

During 1958, Kansas produced mineral fuels, including oil, gas, and coal; nonmetallics, such as stone, clay, salt, sand, and gravel; and the metals Pb and Zn, as well as other minor mineral products, to maintain its position as one of the 10 leading mineral-producing states.

Research carried out by the State Geological Survey of Kansas is directed toward geological and mineral-resource needs of the State's existing and potential industries, as well as for the benefit of the individual citizen. These activities supplement private oil investigations, highway construction, brick-making ventures, water-supply problems, commercial-coal inventories, etc. To date (1958) more than 300 Survey bulletins, maps, and miscellaneous publications have been made available to the public. During the 1957-58 fiscal year, 15 topographic maps were published, 12 were under final review, and 78 were authorized. Rocks, minerals, and fossils were identified; chemical analyses were made; professional and educational conferences were planned and conducted. Five Bulletins were issued during the fiscal year, as well as 4 Oil and Gas Investigations. Eighteen papers by the State Geological Survey members published outside the Geological Survey are listed.

Basic research was conducted in stratigraphy, areal geology and paleontology; palynology; study of well logs and well samples; petrography, mineralogy and x-ray studies. Cooperative studies with the U. S. Geological Survey were made on ground water, irrigation, mineral fuel, and topographic mapping. --G. E. Denegar.

1-1059. [New York State Museum and Science Service, Geological Survey]. GEOLOGICAL RESEARCH IN NEW YORK STATE, 1958: Its: Newsletter no. 10, 13 p., Feb. 1959.

Individual geologic projects undertaken or continued in 1958 in New York are grouped under various headings alphabetically by name of the research worker. Under Precambrian geology, 16 are noted; under general geology, including paleontology and stratigraphy, 50; under glacial geology, 10; under economic geology, 17; and under geophysics and geochemistry, 5. Publications concerning New York geology which appeared during 1958 are also listed, as are 1958 theses on New York geology. --G. E. Denegar.

1-1060. Shatskiy, N. S., and A. A. Bogdanoff. EXPLANATORY NOTES ON THE TECTONIC MAP

OF THE USSR AND ADJOINING COUNTRIES.[1] Translated by Theodore Shabad and C. Muromcew: Internat. Geology Rev., v. 1, no. 1, p. 1-49, map, Jan. 1959.

There are as yet no generally accepted conventional symbols used in small-scale tectonic maps, nor is there an adequate classification of tectonic forms, especially of the major structures of the earth's crust, that might be shown on a topographic base of relatively small scale. The publishers and the compilers of the Tectonic Map of the U.S.S.R therefore thought it necessary to accompany it by a short explanatory note stating the principles used in working out the conventional symbols and describing the basic features of the tectonic structure of the regions of the U.S.S.R. that determine their classification in one or the other of the structural categories.

A large group of geologists took part in the compilation of the Tectonic Map of the U.S.S.R. Some of them have rather divergent views on various questions relating to the tectonic structure of the U.S.S.R., and it was not always possible to reconcile these views in the course of the editorial work. The explanatory note lists the major questions relating to the regional tectonics of the U.S.S.R. that are still in dispute.

A list of the geologists who took part in the compilation of the map appears in a special insert on the map, indicating the sections of the U.S.S.R. and adjoining countries assigned to each person. N.S. Shatskiy was in charge of overall editing of the map.

Others who took part in the compilation and in the preparation of the new tectonic map for publication include staff members of the Geologic Institute of the Academy of Sciences, U.S.S.R., and geologists of the All-Union Geological Scientific Research Institute, Moscow State University, Moscow Geologic Exploration Institute, Institute of Arctic Geology, and other institutions. --Auth. pref.

[1]Published by the State Scientific and Technical Publishing House of Geologic and Conservation Literature, Moscow, 1957.

1-1061. Sloane, Howard N. USE OF DECAMIRED FILTERS IN CAVE PHOTOGRAPHY: Natl. Speleol. Soc., Bull. no. 20, p. 61-63, 3 tables, Nov. 1958.

The Decamired (DM) filters employ a new principle based on the reciprocal of the color temperature and are used to standardize film with light for inside- and outside-cave photography. The DM filters consist of 2 sets of filters. One set has 3 filters in the reddish (R) or warm colors, valued at R3, R6, and R12; the others are bluish (B) or cool colors, valued at B3, B6, and B12. These can be used in various combinations, thus avoiding film changes or off-color photographs. Tables of DM values and light source ratings are given. --G. E. Denegar.

1-1062. Brown, F. Martin. EARTH SCIENCE TRAINING INADEQUATE: GeoTimes, v. 3, no. 6, p. 10-11, March 1959.

An examination of the scientific curricula of school systems in the United States reveals that only the teaching of general science is widespread; very few high schools give courses in the earth sciences. A survey of 203 teachers of general science showed that large percentages of teachers are unsatisfactorily prepared in fields of chemistry, physics, the earth sciences, and mathematics. In only biology and education are these teachers excellently prepared. Training schools for teachers, especially elementary and junior high school teachers, should recognize the need for ground work in the earth sciences, and teachers now trained should take advantage of opportunities to increase their knowledge in these fields. Institutions cooperating with the National Science Foundation should include earth science seminars tailored to the needs of general science teachers. --A. C. Sangree.

1-1063. GEOLOGY ON TV: GeoTimes, v. 3, no. 7, p. 10-11, illus., Apr. 1959.

A 15-week course in introductory geology was presented by C. Wroe Wolfe of Boston University over Boston's educational TV station WGBH from Oct. 1957 to Feb. 1958. No script was prepared for the half-hour show, but a list of materials, photos, and maps was made up prior to each session as an aid to the producer. Kodachrome slides (projected in black and white), rocks and mineral specimens, half tones, maps, and old-style 3 x 4 slides were all satisfactorily reproduced on the TV screen. Most difficult problem was coordination of the TV lecture with the 2-hour lecture being presented to the adult class in the studio. The last half-hour of the class was televised, choosing subjects that were not discussed previously. This Earth of Ours, by Prof. Wolfe, was used as a text. All walks of life were represented in the classroom; less than 50% of the students were seeking credit for the course. Titles of the 15 half-hour programs are given. --A. C. Sangree.

1-1064. Norton, Matthew F., and James L. Kaiser. SHARING THE SCIENTIST: GeoTimes, v. 3, no. 5, p. 12-13, Jan.-Feb. 1959.

The American University Geology Department, in conjunction with personnel from the U. S. Geological Survey and the U. S. National Museum in Washington, D. C., is experimenting with a new type of evening instruction. As a first step, a course in invertebrate paleontology was presented during the Fall 1958 semester, in which a chief instructor-course coordinator was supplemented by specialists in Protozoa, Porifera, Coelenterata, Bryozoa, Brachiopoda, Mollusca, Echinodermata, and Arthropoda. Similar programs could be carried out in other centers of geoscience activity. --G. E. Denegar.

1-1065. Pollack, Jerome M. JUNIOR HIGH GEOLOGY: GeoTimes, v. 3, no. 5, p. 10, illus., Jan.-Feb. 1959.

Seventeen students of the Norman, Oklahoma, Junior High School were taught a 6-weeks course in geology as part of a summer enrichment program. No text was used, but the American Geological Institute made copies of the Boy Scout Geology Kit available, and the University of Oklahoma provided classroom space and physical and historical geology laboratory equipment. One all-day field trip to the Arbuckle Mountains was included. Though the lecture material was presented within a general systematic framework, no attempt was made to keep any rigid order of subject matter. --G. E. Denegar.

1-1066. Slobod, Jeanne L. MINERAL INDUSTRIES ART: GeoTimes, v. 3, no. 7, p. 8-9, 5 illus.,

Apr. 1959.

The art gallery in the Mineral Industries Building at The Pennsylvania State University is probably the only one in the world devoted solely to mineral industries scenes and, as such, has won international recognition. The 143 oil paintings plus several water colors and prints constitute an historical record of mineral activities in Pennsylvania. Paintings include scenes in bituminous and anthracite fields, steel mills, oil fields, lime kilns, coke ovens, stone quarries, brick plants, glass works, and others. Virtually every section of Pennsylvania is represented.

The collection had its beginnings over 25 years ago, largely through the efforts of Edward Steidle, now Dean Emeritus of the College of Mineral Industries. In addition to Penn State students, approximately 10,000 visitors annually visit the gallery. --A. C. Sangree.

1-1067. Greenwood, Robert. EXTRA-TERRESTRIAL GEOLOGY: GeoTimes, v. 3, no. 5, p. 8-9, 26-27, Jan.-Feb. 1959.

The recent inauguration of the National Aeronautics and Space Administration and the appointment of a Space Science Board by the National Academy of Sciences has focused attention on research programs for extra-terrestrial exploration. Investigations of the Moon, Venus, and Mars calls for scientists experienced in the study of large masses of silicate rocks. However, space exploration, in the foreseeable future, will be conducted by unmanned vehicles. These should be able to gather data on temperature, pressure, topographic relief, magnetic field, radiation, seismic behavior, etc.

The extra-terrestrial geologic program is developed in 3 stages: 1) instrument design and testing, 2) creation of a lunar transmitting station, and 3) data gathering and investigation of Venus and Mars by unmanned vehicles. The possibility that Phobos, and especially Deimos, Mars' 2 natural satellites, could serve as natural landing and take-off platforms should be ascertained. Venus, more promising for exploration by unmanned vehicles, is less well-known and would be an excellent target for early study. However, the geological profession must first set up a research program for geological investigations by unmanned vehicles, under the NASA, with the responsibility and facilities for testing its projects on Earth, via Earth satellites; then, when rocket engineers and astronauts produce a vehicle, geologists will be ready with an itinerary and a project. --G. E. Denegar.

AUTHOR INDEX

Abstract

Abuzeid, S. 1-1031
Adler, H. H. 1-977
Ager, D. V. 1-862
Ahmad, S. Siraj 1-890
Alía, M. 1-1010
Ambartsumian, Z L. 1-934
Angelelli, Victorio 1-1004
Archbold, N. L. 1-1000
Armstrong, Augustus K. 1-850
Armstrong, J. E. 1-819
Arnold, J. R. 1-924
Athearn, William D. 1-871
Azároff, Leonid V. 1-929

Baadsgaard, H. 1-858
Baldwin, Robert W. 1-883
Barabás, A. 1-1017
Baragar, W.R.A. 1-821
Barendregt, F. 1-890
Barker, F. B. 1-919
Barnett, P. R. 1-914
Bates, Thomas F. 1-941,1-985
Batulin, S. G. 1-918
Bé, Allan W. H. 1-872
Beall, Robert M. 1-954
Beard, C. Noble 1-841
Bell, K. G. 1-917
Beloussov, V. V. 1-842
Belova, L. N. 1-1019
Berbezier, J. 1-894
Bhatia, S. B. 1-867
Bhola, K. L. 1-1021,1-1022
Bigotte, G. 1-1034
Bills, C. W. 1-972
Biot, M. A. 1-840
Bisir, D. P. 1-899
Blair, Robert G. 1-897
Blangy, B. 1-894
Bloss, F. Donald 1-943
Bode, H. 1-851
Bogdanoff, A. A. 1-1060
Bolli, Hans M. 1-869
Bolostnova, M. B. 1-1057
Bonatti, Stefano 1-945
Bondam, J. 1-987
Bonet, C. 1-1010
Borisenko, L. F. 1-909
Bowie, S.H.U. 1-898
Boyer, W. H. 1-998
Boyle, R. W. 1-962
Boyle, T. L. 1-896
Bradbury, J. C. 1-1044
Brett, S. E. 1-804
Brown, F. Martin 1-1062
Brown, Walter E. 1-940
Bryzgalin, O. V. 1-965
Buerger, Martin J. 1-929
Bulashevich, Yu. P. 1-889
Burger, A. J. 1-1038
Burnham, C. Wayne 1-1046
Buser, W. 1-926
Butler, A. P., Jr. 1-993
Buttler, F. G. 1-938

Cannon, R. S., Jr. 1-978
Carpenter, L. Graydon 1-964
Carrat, H. 1-1007
Carsola, Alfred J. 1-1053
Catalina, F. 1-980
Cavaca, R. 1-1015
Chaloner, W. G. 1-877
Chandler, T.R.D. 1-975
Chatterji, B. D. 1-1021,1-1027
Chervet, Jean 1-979
Chronic, John 1-950
Chupakhin, M. S. 1-920
Clark, David L. 1-875
Clifford, O. C., Jr. 1-1049

Abstract

Coleman, Robert G. 1-935
Collin, C. R. 1-971
Cook, S. F. 1-865
Cooper, H. H., Jr. 1-951
Cooper, S. A. 1-1056
Coppens, René 1-908
Corey, A. T. 1-837
Coulomb, R. 1-979
Crandell, D. R. 1-856
Cullity, B. D. 1-930
Curl, Rane L. 1-830
Currie, K. L. 1-804

Dachille, Frank 1-902
Dahlstrom, C.D.A. 1-843
Dar, K. K. 1-1021,1-1023
de Petro, F. 1-1010
de Quervain, F. 1-891
Derriks, J. J. 1-1033
Deruguine, T. 1-1057
de Villiers, J.W.L. 1-1038
de Villiers, John 1-1048
de Vries, A. E. 1-921
Dewart, Gilbert 1-887
Dickey, Parke A. 1-1050
Dietrich, Richard V. 1-939
Dodd, P. H. 1-994
Dontsova, E. I. 1-920

Eade, K. E. 1-803,1-804
Edwards, G. 1-858
Emery, K. O. 1-949
Ethington, R. L. 1-873
Everhart, D. L. 1-968
Ewing, John 1-886
Ewing, Maurice 1-885,1-886
Ezra, H. C. 1-865

Fahrig, W. F. 1-805
Faris, Barbara 1-923
Faul, Henry 1-888
Fedorchuk, V. P. 1-959
Fernández Polo, J. A. 1-1010
Flint, Richard Foster 1-827
Foster, Roy W. 1-825
Fraser, J. A. 1-802
Frondel, Clifford 1-933
Fujiwara, Shizuo 1-973
Furnish, W. M. 1-874
Fursov, V. Z. 1-961
Fuson, Robert H. 1-922

Gabelman, J. W. 1-998
Gangloff, A. M. 1-971,1-1006
Garcia de Figuerola, L. C. 1-1011
Gard, L. M. 1-856
Garrett, Donald E. 1-964
Geological Society of America 1-810
Germanov, A. I. 1-918
Getseva, R. V. 1-1019
Gillery, F. H. 1-942
Gladishev, G. D. 1-1020
Glaister, R. Perry 1-854
Glasser, L. S. Dent 1-938
Glover, R. E. 1-952
Goddard, Charles C., Jr. 1-960
Goldich, Samuel S. 1-858
Gorsline, Donn S. 1-949
Gottfried, David 1-907
Grammakov, A. G. 1-893
Green, Dale J. 1-833
Green, R. 1-849
Greenwood, Robert 1-1067
Griffith, J. W. 1-988
Griffitts, W. R. 1-1042
Grimbert, A. 1-971
Gritsaenko, G. S. 1-1019
Guitton, J. 1-894

Abstract

Gutschick, Raymond C. 1-861,1-866

Halliday, William R. 1-831,1-833
Handin, John 1-844
Haring, A. 1-921
Harris, L. A. 1-903
Hart, O. M. 1-1001
Hecht, Friedrich 1-976
Henderson, G. G. L. 1-843
Hess, H. D. 1-936
Hewitt, D. F. 1-989
Heywood, W. W. 1-800,1-803,1-804
Higazy, R. A. 1-1031,1-1032
Higgs, Donald V. 1-844
Hill, Dorothy 1-860
Hilpert, L. S. 1-1002
Hinault, J. 1-1034
Hodder, R. W. 1-1041
Honda, M. 1-924
Hope, E. R. 1-847
Houtermans, F. G. 1-926
Howell, B. F., Jr. 1-880
Hower, John 1-901
Hügi, Th. 1-891
Hummel, F. A. 1-904
Hunt, A. D. 1-852
Hutt, G. M. 1-1045
Hutton, C. Osborne 1-937

Illsley, C. T. 1-972
Ippolito, Felice 1-1016

Jantsky, B. 1-1018
Jedwab, J. 1-974
Jeffords, Russell M. 1-859
Jeletzky, J. A. 1-853
Johnson, J. C. 1-967
Jones, Daniel H. 1-859
Judson, Sheldon 1-1055

Kaiser, James L. 1-1064
Kansas, State Geological Survey 1-1058
Karim, S. M. 1-890
Katayama, Nobuo 1-1028
Kerr, Paul F. 1-999
Keys, W. S. 1-994
Khattab, A. 1-1031
Khitarov, N. I. 1-927
Khoroshilov, L. V. 1-982
Kiss, Jean 1-963,1-1017,1-1018
Kisslinger, Carl 1-884
Kjellesvig-Waering, Erik N. 1-864
Koehler, G. F. 1-962
Konizeski, R. L. 1-955
Kornicker, Louis S. 1-876
Koseki, Kôji 1-1029
Kratchman, Jack 1-969
Krylov, A. Ya. 1-911
Kuegelgen, H. v. 1-846
Küpper, Heinrich 1-976
Kushnarev, I. P. 1-982
Kvashnevskaya, N. V. 1-893
LaChapelle, E. R 1-828
Lallemant, C. 1-894
Landes, Kenneth K. 1-839
Lang, A. H. 1-988
Larsen, Esper S., Jr. 1-907
Lattman, Laurence H. 1-1051
Lebedeva, N. E. 1-927
Leconte, J. R. 1-1034
Lecoq, J. J. 1-1034
Lee, H. A. 1-803
Leet, L. Don 1-1055
Lengyel, S. 1-1018
Lenoble, A. 1-1006
Leopold, Estella B. 1-950
Lewis, D. R. 1-931
Liebenberg, W. R. 1-1035
Link, Cord H., Jr. 1-832
Lisitsin, A. K. 1-918
Lizunov, N. V. 1-909

Abstract

Loomis, Tom H. W. 1-897
Lukin, L. I. 1-982

McIntire, William G. 1-826
McKee, Edwin D. 1-950
MacKevett, E. M., Jr. 1-997
McMurtrey, R. G. 1-955
Mabile, J. 1-1009
Mahadevan, C. 1-1025,1-1026
Maldonado-Koerdell, M. 1-900,1-947
Malyuga, D. P. 1-958
Mandarino, Joseph A. 1-932
Mapper, D. 1-905
Mårtensson, Carl 1-1005
Martinelli, M., Jr. 1-829
Mason, R. G. 1-881
Mawdsley, J. B. 1-991
Maync, Wolf 1-868
Mehta, N. R. 1-1022
Melnikov, I. V. 1-1020
Merrill, J. R. 1-924
Meyer, Gerald 1-954
Meyers, Arnold 1-834
Miller, J. M. 1-898
Mingarro, E. 1-980
Mirchink, M. F. 1-1052
Moench, R. H. 1-1002
Molloy, Marjorie 1-907
Moore, Richard T. 1-811
Morgan, J. W. 1-905
Morgan, James P. 1-826
Moxham, R. L. 1-962
Moxham, R. M. 1-895
Muller, Jan 1-878
Mullineaux, D. R. 1-856
Murakami, Yukio 1-973
Murakoshi, Tsukasa 1-1029
Murphy, Daniel L. 1-822
Murray, John W. 1-939
Mytton, J. W. 1-914

Nagaraja Rao, N. 1-1026
Naguib, A. G. 1-1031,1-1032
Nandi, H. 1-1023
Narayana Das, G. R. 1-1026
Nekrasova, Z. A. 1-984
Nel, L. T. 1-1036
Nesterenko, G. V. 1-912
Neves Ferrão, C. 1-1013
New York State Museum and Science Service,
Geological Survey 1-1059
Nicolaysen, L. O. 1-1038
Nikolaev, V. A. 1-845
Nikonov, A. I. 1-893
Nininger, R. D. 1-966
Norton, J. J. 1-1042
Norton, Matthew F. 1-1064

Ohashi, Shuji 1-973
Oosterbosch, R. 1-1033
Ortega, Armando 1-1004

Page, Lincoln R. 1-970
Page, Richard A. 1-855
Palmer, H. C. 1-962
Panhandle Oil Explorer 1-817
Parker, Frances L. 1-871
Perry, T. G. 1-861
Petrascheck, Walter E. 1-976
Pickup, J. 1-898
Pierce, A. P. 1-914
Pike, D. R. 1-1037
Pires Lobato, C. 1-1013,1-1014
Podolsky, T. 1-801
Polikarpova, V. A. 1-934,1-1020
Pollack, Jerome M. 1-1065
Pollock, J. W. 1-972
Pomirleanu, V. V. 1-928
Poole, W. H. 1-808
Poughon, A. 1-1007
Poulter, Glenn J. 1-813

Abstract

Press, Frank 1-885,1-887
Pryor, Edmund J. 1-956

Rafalsky, R. P. 1-983
Ramirez, E. 1-1011
Rasumnaya, E. G. 1-915
Ratcliffe, J. D. 1-852
Rebollo, J. L. 1-1010
Rengarten, E. V. 1-927
Rhoden, V. C. 1-888
Robinson, S. C. 1-988,1-989
Roscoe, S. M. 1-823,1-988,1-990
Rosholt, John N., Jr. 1-925
Roubault, Marcel 1-908
Rowland, R. A. 1-931
Roy, Rustum 1-902
Rozhkova, E. V. 1-915
Russell, R. T. 1-995
Rybalov, B. L. 1-982

Sahasrabudhe, G. H. 1-1022
Sanselme, H. 1-971,1-1007
Santana Pérez, D. 1-1012
Sarcia, J. A. 1-1007,1-1008
Sastry, B. S. R. 1-904
Sato, Motoo 1-973,1-1030
Savelyeva, K. T. 1-1019
Savinova, Ye. N. 1-912
Savul, M. A. 1-928
Schleusener, Richard A. 1-837
Schufle, J. A. 1-882
Schworm, Robert E. 1-836
Scott, R. C. 1-919
Scull, B. J. 1-948
Serebrennikov, V. S. 1-918
Serebryakova, M. B. 1-915
Shabad, Theodore 1-1039
Shatskiy, N. S. 1-1060
Shawe, Daniel R. 1-1000
Shcherbak, O. V. 1-915
Shcherbina, W. V. 1-981
Shekarchi, Ebraham 1-943
Shell, H. R. 1-943
Shevaleevskii, I. D. 1-913
Shirke, V. G. 1-1027
Sidorenko, G. A. 1-910
Simmons, G. C. 1-1000
Sinex, F. Marott 1-923
Singh, S. K. 1-867
Skřivánek, František 1-835
Sloane, Howard N. 1-1061
Slobod, Jeanne L. 1-1066
Smales, A. A. 1-905
Smith, Clay T. 1-814
Smith, G. H. 1-975
Smith, G. W. 1-838
Smith, James P. 1-940
Smyslov, A. A. 1-892
Sochevanov, N. N. 1-893
Sokolov, M. M. 1-893
Solow, Herbert 1-957
Sonyushkin, E. P. 1-982
Sörensen, H. 1-987
Steacy, H. R. 1-988,1-990
Stearn, C. W. 1-824
Stermitz, Frank 1-955

Abstract

Stern, T. W. 1-978
Stieff, L. R. 1-978
Stone, G. L. 1-874
Strahl, Erwin O. 1-985,1-986
Strain, W. S. 1-857
Studenikova, Z. V. 1-912
Suppe, S. A. 1-893
Swanson, V. E. 1-917
Sweet, Walter C. 1-863
Swenson, H. A. 1-955
Szalay, A. 1-916
Szy, D. 1-1018

Tafeyev, G. P. 1-893
Tananayeva, G. A. 1-1020
Taylor, F. C. 1-806
Taylor, H. F. W. 1-938
Tedlie, W. D. 1-820
Tishkin, A. I. 1-1020
Treckman, John F. 1-866
Tremblay, L. P. 1-807,1-992
Trumpour, H. J. 1-936
Tsibulskaya, M. S. 1-1020
Tugarinov, A. I. 1-910,1-913
Turanskaya, N. V. 1-910
Tuzova, A. M. 1-913

Udas, G. R. 1-1022,1-1024
United Nations, Economic Commission for
Asia and the Far East 1-1047
U. S. Geological Survey 1-809,1-818

Vainshtein, E. E. 1-910,1-913
Vaughn, W. W. 1-888
Vine, J. D. 1-917
Vineyard, Jerry 1-953
Vinogradov, A. P. 1-906,1-920
Virágh, K. 1-1018
Volkov, G. A. 1-918
von Gunten, H. R. 1-926

Waagé, K. M. 1-812
Wada, Koji 1-946
Wadia, D. N. 1-1043
Weaver, C. E. 1-858
Webster, R. K. 1-905
Weeks, Alice D. 1-933
Weiss, E. J. 1-931
Welin, Eric 1-1005
Wessel, F. W. 1-1040
Williams, D. 1-898
Wilmarth, V. R. 1-1042
Wilson, E. E. 1-888
Wilson, Eldred D. 1-811
Wilson, J. Tuzo 1-879
Wood, A. J. 1-905
Woodmansee, W. C. 1-996
Wyllie, P. J. 1-944

Yrigoyen, Marcelo R. 1-1003

Zalesny, Emil R. 1-870
Zeller, Robert A., Jr. 1-815,1-816
Zhemchuzhinikov, Y. A. 1-848
Zumberge, James H. 1-1054